UNIVERSIDADE DE LISBOA

Faculdade de Medicina Veterinária

ESTIMATION AND CHARACTERIZATION OF THE DOG AND CAT POPULATION ON MAIO ISLAND, CAPE VERDE: AN INTEGRATION OF HOUSEHOLD SURVEY DATA AND REMOTE SENSING IMAGERY

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DISSERTAÇÃO DE MESTRADO INTEGRADO EM MEDICINA VETERINÁRIA

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Djarmai di meu

Sodade más profundo
Qui tudo mar dja navegado!
Nha tchon, nha mund calado
Na banda squerda di nha peto

Oh inocéncia doce,
Djarmai di meu.
Cordâ, Pinoso,
Cordâ pa nha regress

Bu sono é dor di pai
É fé di mãe.
Cordâ bu cantâ
Mund inter
Bu puréza

My Island, Maio

Deeper regrets
Than any sea already sailed
My land, my secret world
To the left of my breast

Oh, sweet innocence
My own Island, Maio
Wake up, Pinoso
Wake up and welcome
We back

Your sleep is the sleep
Of a sufering father
Your faith is the faith of a mother
Wake up and sing your purity
To the whole world

Adalberto Silva (Betú)

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Abstract

ESTIMATION AND CHARACTERIZATION OF THE DOG AND CAT POPULATION ON MAIO ISLAND, CAPE VERDE: AN INTEGRATION OF HOUSEHOLD SURVEY DATA AND REMOTE SENSING IMAGERY

Objective: To estimate and characterize the dog and cat population on Maio Island, Cape Verde, in order to provide a baseline to set up a syndromic surveillance system.

Methods: The study was carried out in the course of *Vétérinaires Sans Frontières* - Portugal mission. One team applied questionnaires in six localities to classify the animals according to their age, gender, sterilization and parasites control status, body condition, skin changes and other observations, degree of dependence and restriction and recorded the coordinates of feeding places for each animal. Other team registered animal's clinical information in Porto Inglês where companion animal health and welfare campaigns were performed. Geographic information systems tools were used to process the data and linear regression models were created with the number of houses as only predictor variable to estimate dog and cat populations.

Results: In the observed dog population (n=457), 19.7% of the animals were sterilised, 23% dewormed; 1% was classified as feral and 0.88% as neighbourhood dogs. For cats (n=306), the results were 13.7%, 16%, 0.33% and 2.29%, respectively. The estimated population size on the island was 531 dogs and 354 cats. The models for these estimations were based on 400 m and 200 m resolutions respectively and resulted in an error of 7% when compared to survey results.

Conclusions: This study highlights the potential of geographic information systems in population size estimates and praises the efforts done by non-governmental organizations on this island in order to promote public health.

Keywords: Animal population size estimative, Maio Island, Cape Verde, Geographic information systems, Household survey, Remote sensing imagery.

Resumo

ESTIMATIVA E CARACTERIZAÇÃO DA POPULAÇÃO DE CÃES E GATOS NA ILHA DO MAIO, CABO VERDE: INTEGRAÇÃO ENTRE DADOS DE UM RECENSEAMENTO E IMAGENS DE DETECÇÃO REMOTA

Objectivo: Estimar e caracterizar a população de cães e gato na ilha do Maio, em Cabo Verde, de modo a recolher informação para implementar um sistema de vigilância sindrómica.

Métodos: O estudo foi realizado no decurso da missão dos Veterinários Sem Fronteiras - Portugal. Uma equipa realizou questionários em seis localidades para classificar os animais de acordo com a sua idade, género, esterilização e controle de parasitas, condição corporal, alterações cutâneas e outras observações, o grau de dependência e de restrição e, registou ainda, as coordenadas dos locais de alimentação para cada animal. Outra equipa registou a informação clínica dos animais em Porto Inglês durante as campanhas para promover a saúde e o bem-estar dos animais de companhia. Foram utilizadas ferramentas de sistemas de informação geográfica para processar os dados e foram criados modelos de regressão linear, tendo o número de casas sido definido como única variável independente para estimar a população de cães e gatos.

Resultados: Na população de cães observados (n = 457), 19,7% dos animais estavam esterilizados, 23% desparasitados, 1% foi classificado como não tendo dono e 0,88% como animais de bairro. Para gatos (n = 306), os resultados foram de 13,7%, 16%, 0,33% e 2,29%, respectivamente. A estimativa da população na ilha foi de 531 cães e 354 gatos. Os modelos para estas estimativas foram construídos com base nas resoluções de 400 m e 200 m respectivamente e resultaram num erro de 7% quando comparado com os resultados do recenseamento.

Conclusões: Este estudo destaca o potencial dos sistemas de informação geográfica na estimativa de populações animais e enaltece os esforços feitos por organizações não-governamentais nesta ilha, com o objectivo de promover a saúde pública.

Palavras-chave: Estimativa da população animal, Ilha do Maio, Cabo Verde, Sistemas de informação geográfica, Questionários, Imagens de detecção remota.

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List of Abbreviations and Acronyms

F - Factor

F1 - Factor 1 (pixels size= 100 m, area=1 ha)

F2 - Factor 2 (pixels size= 200 m, area=4 ha)

F4 - Factor 4 (pixels size= 400 m, area=16 ha)

F5 - Factor 5 (pixels size= 500 m, area=25 ha)

F8 - Factor 8 (pixels size= 800 m, area=64 ha)

F10 - Factor 10 (pixels size= 1000 m, area=100 ha)

GIS - Geographic Information Systems

GPS - Global Positioning System

hab - habitant

MS - Mean square prediction error

Nr - number

VSF - Portugal - *Vétérinaires Sans Frontières* - Portugal

WHO - World Health Organization

WSPA - World Society for Protection of Animal

R^2 - Coefficient of determination

1. Introduction

1.1. Introduction and objectives

Animal health has an impact on public health. Several zoonoses have the potential to cause morbidity and mortality in humans but also cause serious disease in agricultural and food-producing animals. In order to prevent these possible effects, many countries implemented epidemiological surveillance systems to control and monitor epizootics outbreaks (Mandl et al., 2004).

Modern One Health tends to focus on zoonotic pathogens emerging from wildlife and production animal species (Day, 2011), underestimating the impact of companion animals. Companion animals are responsible for transmitting several diseases, such as toxoplasmosis, Lyme disease**,** intestinal parasites (Roundworms and Hookworms) and rabies. In fact, rabies remains one of the most serious zoonoses worldwide (World Health Organization [WHO], 2012).

The motivation for this research was to estimate the dog and cat population on Maio Island, Cape Verde, in order to implement a syndromic surveillance system as part of *Vétérinaires Sans Frontières* - Portugal (VSF-Portugal) project "Public Health trough Animal Health". The general objective of this program is to provide an infrastructure for setting up a network to communicate and manage disease information to a central coordination center, in order to plan surveys and conduct epidemiological analyses using syndromic surveillance methods. This program could guarantee the success of animal health management programs, promoting animal and public health on the island.

In this dissertation, a comprehensive literature review was performed according to the objectives and is documented in Chapter 2. It provided important background for this work.

The substantive research objectives documented in the following chapters of this dissertation, were:

- Chapter 3: Description of the survey design including the following tasks: the target populations, the process and steps through which the data were collected, the measurement instruments and the sampling units. This chapter includes description of the methodology approach used to obtain, explore and analyse the data. This chapter also covers the data analysis including the motivation for choosing specific analytical procedures (statistical tests) and references to the software used to analyse the data.

- Chapter 4: This chapter presents the results of the data analysis.
- Chapter 5: The purpose of this section is to place results in the research context, providing interpretations and opinions. This includes the evaluation of data collection procedures; comments about its success and effectiveness; discussing other important and directly relevant issues and make suggestions for future research.
- Chapter 6: States the most important outcomes and perspectives of this project in a summarised module.

1.2. Training description

The present dissertation is a result of the work developed during nine months of traineeship, which represented a total of 1320 hours in fulfilment of requirements for obtaining the degree of Master of Veterinary Science at Faculty of Veterinary Medicine of University of Lisbon (FMV-ULisbon). The training period took place at FMV - ULisbon, at Avia-GIS (Belgium) and in Maio Island (Cape Verde), under the theme of "Estimation of the dog and cat population on the island of Maio, Cape Verde, based on Remotely Sensed Data".

From September 10^{th} to December 21^{st} 2012, my training period took place at the Department of Animal Production and Food Safety of FMV - ULisbon, representing a total of 600 hours of training. My co-supervisor, Dr Telmo Nunes introduced me to the subjects of advanced veterinary epidemiology, data management, and software training.

The literature review was performed focused on methodologies for estimating animal populations in order to plan which strategy would be selected for collecting data on Maio Island.

From the 12^{th} to 26^{th} October of 2012 I took part of the VSF-Portugal mission to this island. I visited several localities in order to collect data to develop this project and I also gave support during the companion animal health and welfare campaigns developed in Porto Inglês. Initially, the aim of the survey was to estimate the dog, cat and swine populations. The questionnaires developed to gather information about swine population were carried out at the same time as the dog and cat questionnaires in all households. Unfortunately, the fact that the piggeries were dispersed in a fairly wide area surrounding the localities led to a lack of time to record their positioning location. These results were not included in this dissertation since it was not possible to collect the data essential to build a predictive model in order to estimate the swine population on the island.

From 20th to 22nd of November, I attended the course “Formação em Análise SIG com Quantum GIS”, by FAUNALIA, Lda., in Torres Vedras, Portugal.

The first approach to data management and descriptive statistics was performed at FMV in order to develop new epidemiological skills using Geographical Information Systems Software. These activities were developed using Microsoft® Excel, Quantum GIS and R program.

The second half of the training took place at Avia-GIS, in Belgium, from January 7th to May 24th 2013, representing a total of 720 hours of training engendered through the ERASMUS Programme. It was dedicated to continue data analysis and processing, as well as software learning (ArcGIS™ and R Studio). I also performed research to identify peer-reviewed and grey literature about the state of the art of syndromic surveillance system in veterinary and human health including methodologies and tools that can be adapted to data sparse environments. The algorithms commonly used for syndromic surveillance and communication systems were also reviewed. I performed several presentations at Avia-GIS, Hasselt University and Ghent University in order to develop my communication skills. In addition, a proposal was elaborated and accepted for evaluation in order to apply to a PhD mandate funded by the Flemish Agency for Innovation by Science and Technology and to be taken at Avis-GIS, which was not approved for funding.

Furthermore, I submitted a successful application for a bursary to the 2013 Annual Meeting of the Society for Veterinary Epidemiology and Preventive Medicine (SVEPM) in Madrid. I attended the conference and I presented the poster entitled “Estimating dog population on Maio Island, Cape Verde”, available at www.svepm.org.uk. I participated on the Poster tour and this poster received one of the three 2013 SVEPM poster prizes. Furthermore, I attended to the workshop “Data mining and machine learning: What’s their relevance to a veterinary epidemiologist?”.

2. Literature Review

The search for studies involved five separate approaches, limited to the years 1984–2013:

- searches in electronic databases for peer-reviewed articles (PubMed, Science Direct, SciVerse-HUB, BioMed Central, Elsevier, Plos One, Wiley Online Library, Scientific Electronic Library Online and Google Scholar);
- hand searches through the proceedings from Epidemiology, Biostatistic, Geographic information systems and Remote sensing data books;
- searches through previous literature reviews and reference lists of papers;
- Pubcrawler Notification subscription;
- electronic grey documents review (periodicals: journals and blogs).

Scientific literature was reviewed using the following keywords: estimation of animal population, ecological niche, wild animal's surveys, stray dogs count, zoonoses transmitted by companion animals, One Health concept, rabies outbreak, syndromic surveillance systems, animal health systems, public health, Cape Verde, developing countries, geographic information systems and remote sensing data.

Electronic grey literature was searched using those terms; a search using these terms translated to Portuguese was also performed.

The search was last updated in May 2013. Due to the lack of peer review about certain subjects, it was necessary include studies from the last three decades.

As introduction, Cape Verde and Maio Island are described, including the socio-economic activities, animal health and veterinary services on the island.

The next refers to the interactions between humans and domesticated animals and zoonosis concept, stressing the importance of companion animal's health on public health.

The importance of surveillance systems were also explored in the literature review.

A cursory look at dog and cat population estimates methodologies revealed that this is a limited field, and specific methodologies for these animal species were hard to obtain. Therefore, the review covers not only studies for estimating dog and cat populations and guidelines for counting stray dogs but also methodologies applied for wild animal populations.

2.1. Description of Maio Island, Cape Verde

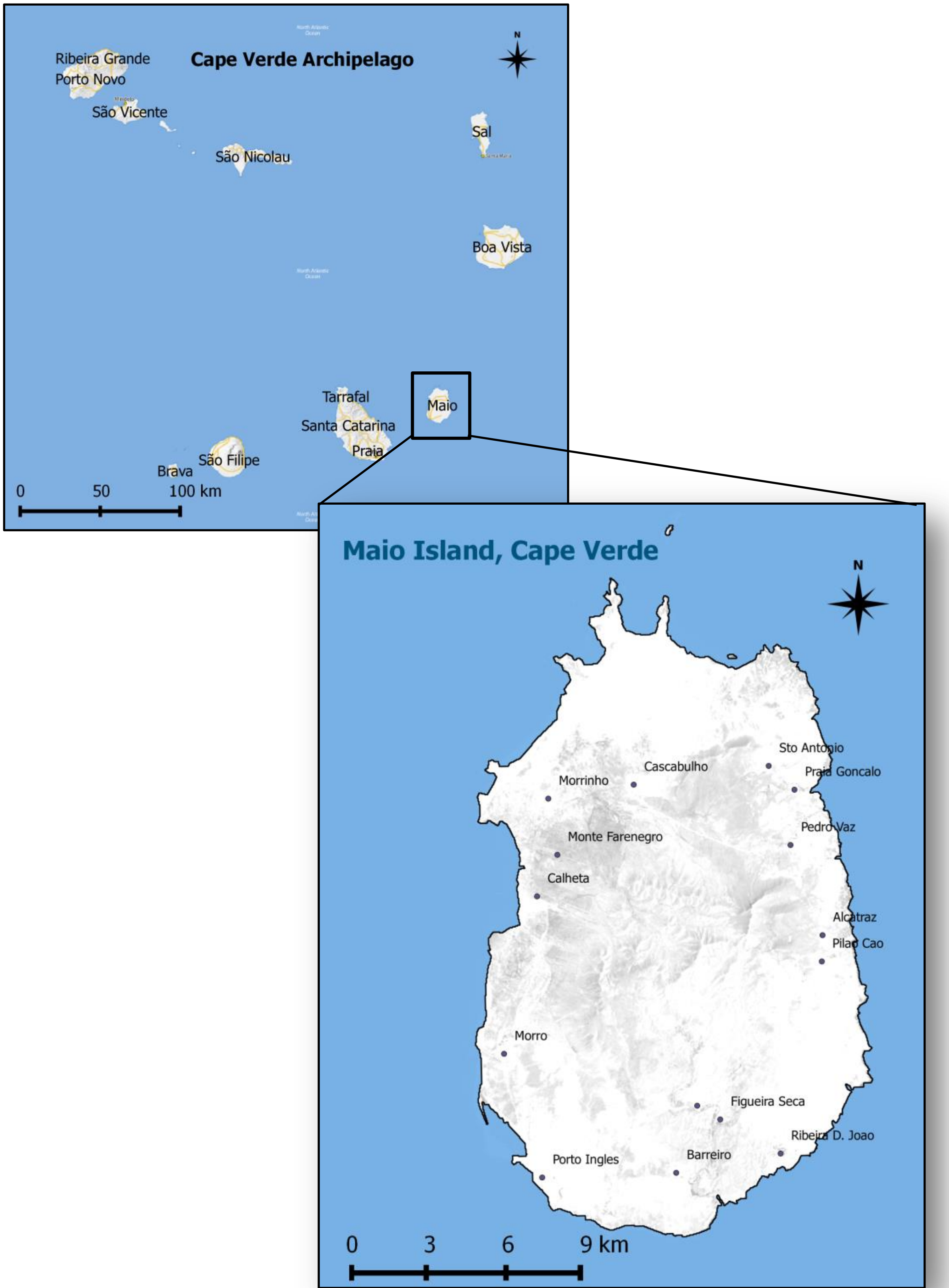
The Cape Verde archipelago is located on the eastern limit of the North Atlantic, about 450 km from the west coast of Africa and 1400 km south-west from Canary Islands.

The Cape Verde archipelago consists of 10 islands distributed in a “C” shape with an opening to the West (figure 1). Depending of the prevailing winds (the trade winds from the northeast) is usual to divide the archipelago of Cape Verde into two groups: (i) Windward (Barlavento) and (ii) Leeward (Sotavento). The first consists of Santo Antão, São Vicente, Santa Lúzia, São Nicolau, Sal and Boa Vista Islands. The Sotavento group includes Maio, Santiago, Fogo and Brava Islands (Costa, Alves-da-Silva & Ventura, 2011; Lima & Garcia, 2011).

The Maio Island is located south of Boa Vista Island, 25 km east of Santiago and extends between parallels 15°7' and 15°20' North latitude and between longitudes 23°5' and 23°15' West longitude, with a maximum length of 24.100 m from North to South, and a maximum width of 16.300 m, West to East, and the total area of 269 km² (Costa et al., 2011). This island is characterised by extensive flat surfaces, with a small mountain range at the centre and surrounding dunes. The highest point of the island is Penoso Mount where it reaches an altitude of 436 m. The island is also known for its large forest which is unusual for Cape Verde.

The island population was 6.952 people and the population density was 25.0/km² in 2010 (Instituto Nacional de Estatística [INE], 2012). The population tends to live in the coastal regions, where it main activity are developed, such as fishing. In addition to this socio-economic activity, the population is mainly dedicated to agriculture, although the scarcity of water and its salinity has led to the abandonment of many farmlands (Lima & Garcia, 2011). The localities are: Alcatraz, Barreiro, Calheta, Figueira da Horta, Figueira Seca, Monte Farenegro, Morro, Morrinho, Pedro Vaz, Pilão Cão, Praia Gonçalo, Ribeira de D. João, Santo António and Porto Inglês (main city).

Figure 1 - Cape Verde Archipelago and Maio Island (adapted from Yahoo! Maps, Driving Directions, Satellite View and Traffic (http://maps.yahoo.com/).



2.2. Veterinary services and animal health in Cape Verde

Similarly to other countries, Cape Verde has a centralised official veterinary service. According to Noguera & Barbosa (2007), the main problems faced by this service are the low number of technical and qualified staff and the limited availability of financial resources to deal with extensive production systems.

Livestock farming takes place in rural and periurban areas and represents a very important subsistence for families (Nogueira & Barbosa, 2007). This activity have an important role in the country, giving advantages to farmers such as access to micro-credits, employment, financial security, socio-economic stature and therefore improvement in living conditions and quality of life. For this reason, many efforts have been carried out by the Veterinary Services to strengthen capacities for disease diagnosis, control, and for epidemiological surveillance in livestock, including vaccination against swine erysipelas and anthrax, tuberculosis and brucellosis control campaigns in cattle.

For companion animals, vaccination, deworming and sterilisation programs are not applied at national level, but several initiatives from Municipalities and Non-Governmental Organizations are on-going, reducing potential risks for public health.

Several research studies have been carried out in order to collect information on dog health.

A survey performed in Praia, Cape Verde by Götsch et al. (2009) revealed the presents of two species of protozoa (*Babesia canis vogeli* and *Hepatozoon canis*) and two species of rickettsiae (*Anaplasma platys* and *Ehrlichia canis*) in 101 dogs, representing 77.7% in a total of 130 dogs.

Vétérinaires Sans Frontières - Portugal (2010-2011) and Castanheira (2012) analyzed respectively 93 and 53 feces samples collected on Maio Island. Results shows that from the 2010 sampling, viral nucleic acid was detected in 43,3% samples for Canine parvovirus, 11,3% for Canine distemper virus and 1,9% for Canine coronavirus and in 2011, the prevalence was 44,1%, 0% and 1,1% for the same agents respectively.

Recently, Pereira et al. (2013) reported the first case of *Dirofilaria immitis* in Cape Verde on a seven-year old mongrel female dog, which exhibited severe generalized adenomegaly and a poor body condition.

There are no official records about the dog and cat populations in Cape Verde. According to periodicals and animal welfare organisation websites, stray dogs have been a major concern in this country, especially in Praia, Mindelo, Santa Maria and São Filipe (A Semana, 2012;

Associação - SOS Cães e Gatos de Cabo Verde Santa Maria, Ilha do Sal, Cabo Verde, 2012). This concern results from the important relationship between companion animals and humans, which can have an impact on public health and on the environment, especially focused on the transmission of zoonoses, such as mange, physical injuries resulting from dog's bites and the negative impact on tourism and environment.

2.3. Interactions between humans and domesticated animals

Most relationships that people maintain with animals are with domesticated ones, especially companion animals.

Domesticated animals play an important role in human societies, such as enjoyment, food and clothing production, for religion, for transportation and draught power, for sport, research, recreation and gambling; for warfare, hunting, tracing and protection; for nature conservation, assisting disabled and shepherds; for obtaining social status and social support (Bokkers, 2006).

The reasons for keeping companion animals and use of veterinary assistance tend to be different, according to the culture, status and economic activities of people (Oboegbulem & Nwakonobi, 1989). In both urban and rural areas they are usually abundant, though largely undefined populations of owned and stray animals.

Demographic evolution of human populations and the tendency for urban concentration have deeply changed the sort of relation with different animal species that followed him up to urban environments. This fact results in an increase of the biological hazards and other dangers resulting from such interaction (Swabe, 1999). This interaction risk is likely to exist in many high density urban areas. The close proximity between households leads to high animal densities, combined with little animal movement restriction results in high contacts between animals (Perry, 1993).

According to Plaut, Zimmerman & Goldstein (1996), the biological and physical hazards should be divided into three categories: (a) infectious diseases associated with animals; (b) immunologic responsiveness to animals; and (c) injuries due to physical interactions with animals.

The first category includes bacterial, viral, parasitic and fungal diseases (Plaut et al., 1996; Geffray, 1999). The keyword in this category is the term zoonosis, which is used to classify any disease or infection that is naturally transmissible from vertebrate animals to humans or viceversa (Pan American Health Organization & Acha, 2003). They are caused by all types of agents: bacteria, parasites, fungi and viruses.

According to Taylor, Latham & Woolhouse (2001), 1415 species of infectious organism are pathogenic to humans, of which 868 (61%) are zoonotic. Humans can get infected either by direct contact with animals (e.g. faeces, skin, saliva, urine) or by indirect contact (water and food that has been contaminated with infectious secretions of an animal) (Plaut et al., 1996). It is important to refer that 132 (75%) of emerging pathogens are zoonotic, and therefore zoonotic pathogens are twice as likely to be associated with emerging diseases as non-zoonotic pathogens (Taylor et al., 2001).

The vectors could be responsible for disease spread and maintenance. Vector could be defined as "a living organism that transmits an infectious agent from an infected animal to a human or another animal" (Carmelo et al., 2012). They can transmit infectious diseases actively, like arthropods, which may carry pathogens that can multiply within their bodies and be delivered to new hosts, usually by biting; or passively, such as flies can pick up infectious agents on the outside of their bodies and transmit them through physical contact. Diseases transmitted by vectors are called vector-borne diseases and many are zoonotic. Some vectors are able to move considerable distances or being introduced to new geographic areas by animal movement, migratory birds, and travel of humans or international trade (Carmelo et al., 2012). The environmental factors, such as climate change and growing population of animal reservoir hosts, may play a role in their establishment and persistence in certain areas.

Many emerging health issues are associated with increasing contact between humans and animals, the expansion of international travel and intensification and integration of food production (WHO, 1999).

The expanding interface or increased interaction between livestock and wildlife also increases the risk of disease incidence and the emergence of new diseases or the re-emergence of previously diagnosed diseases. The risk is not only related to domestic and wild animal health, but also to the occupational hazards that exposes animal handlers and the consumers of meat, milk and eggs. Thus, emergence and re-emergence of zoonotic diseases present challenges not only to veterinarians, but also to all professions concerned with public health.

Factors that may affect the zoonosis impact include length of time the animal is infective, length of the incubation period in animals, stability of the agent, population density of the animals, husbandry practices, maintenance procedures and control of wild rodents and insects, virulence of the agent and route of transmission (Meslin, 1992).

Several zoonotic diseases are transmitted by dogs and cats to humans by their close contact. In some cases, these diseases have as reservoir hosts wildlife and livestock animals.

Staphylococci are found on all animals that typically are associated with humans and, in the great majority of the cases, animals are asymptomatic. However, these bacteria are generally limited to the skin and eye infections and can spread to humans through contaminated hands and objects (Hines, 2012). Transmission of Methicillin-Resistant Staphylococcus Aureus (MRSA) infections between domesticated animal and humans are increasing, with the most common being infections of the skin, soft-tissue and surgical infections (Ferreira et al., 2011). Dog or cat bites can result in infection, caused by bacteria from the animal's mouth and on the patients' body. Animals are potential reservoirs and can potential the cycle between animals and their human acquaintances.

Toxoplasmosis is caused by a protozoan with worldwide distribution, *Toxoplasma gondi.* It is able to infect all warm-blooded animals and invade multiple cell types within these animals. Seroprevalence vary between countries and geographical regions, but overall is high in the global human population (Tenter, Heckeroth & Weiss, 2000). Contaminations could occur orally through the ingestion of meat containing tissue cysts and tachyzoites (horizontal transmission); food and water with oocysts or transplacentary by tachyzoites (congenital; vertical transmission). Acute infection in healthy people most frequently is asymptomatic or manifests with non-specific symptoms. Some people can develop chronic toxoplasmosis, which most frequently is asymptomatic but persistent infection (Gagne, 2001). Acute toxoplasmosis in pregnant women could cause death or serious pathology of the foetus. Immunocompromised people may manifest serious clinical diseases with lesions located in the central nervous system (Gagne, 2001).

Rabies is a zoonotic disease caused by a virus. It is known to be present in all continents except Antarctica and infects domestic and wild animals (WHO, 1999). It is spread to people through close contact with infected saliva via bites or scratches. The main route of rabies transmission to humans is the bite of rabid dogs and is nearly always fatal when left untreated. Excellent vaccines exist to protect humans and animals (WHO, 1999; Hines, 2012).

Lyme disease is caused by the bacterium *Borrelia burgdorferi* and it is transmitted to humans through the bite of infected blacklegged ticks. Typical symptoms include fever, headache, fatigue, and a characteristic skin rash called erythema migrans. If left untreated, infection can spread to joints, the heart, and the nervous system (Bratton, Whiteside, Hovan, Engle, & Edwards, 2008).

In Annex 1, others zoonotic diseases which could be transmitted by dogs and cats are described.

The second category of biological and physical hazards includes allergic disease, asthma and/or hypersensitivity pneumonitis. Cats cause the greatest part of the animal-related allergic reactions (Plaut et al., 1996).

At last, physical interactions with animals can cause tissue damage and may induce infections through biting and scratching (Björnstig, Eriksson & Örnehult, 1991).

It is also important to consider the environmental pollution caused by animals when defecating, urinating or vomiting in public spaces and the nuisance of sound, smell and parasites (flees, ticks, mites) that companion animals can create for people (Louzã, 2007).

Recognizing that domestic animals present a threat to human health it is accepted that successful management programmes depend upon a thorough knowledge of the population's ecology and relationships with man (WHO & WSPA [World Society for the Protection of Animals], 1990; Fekadu, 1993; Butler & Bingham, 2000). These programs should be focused on One Health concept, which is defined as "the collaborative effort of multiple disciplines to attain optimal health for people, animals and the environment" (American Veterinary Medical Association [AVMA], 2008). To accomplish its goal an intersectional collaborative approach is essential, which includes the collaboration among stakeholders, institutions and systems at all levels.

2.4. Importance and components of surveillance systems

The importance of interactions between human and animal populations, the potential for rapid country spread of emerging pathogens and the appreciation of the need to carry out surveillance requires new approaches (Halliday et al., 2012). Effective use of surveillance depends on the system integration with public health and veterinary authorities for outbreak detection, investigation and response management. For this reason, veterinary network, which includes veterinarians and veterinary technicians, play an important role in this subject being responsible for detecting and further reporting diseases in animal populations.

Many developing countries have high rates of staff turnover, laboratory, and infrastructure limitations and difficulties with internet access and other communication tools, which hinder effective surveillance (Chretien et al., 2008; May, Chretien & Pavlin, 2009). Possibly the greatest barrier to reporting, particularly within resource-poor systems, has been that efforts to submit diagnostic samples or disease reports often do not result in any feedback (Halliday et al., 2012).

Due to the lack of financial resources and infrastructures in these countries, surveillance should be based not only on the laboratory confirmed diagnosis of diseases but also on non-specific health indicators including clinical signs, symptoms as well as proxy indicators (e.g. drug sales, animal production collapse) that constitute a syndrome – its observation, recording and communication constitutes ”syndromic surveillance” (Mandl et al., 2004). Therefore, all changes in behaviour, activity and clinical presentation are potentially useful types of data. Examples may include monitoring seasonal mortality patterns, tracing specific sets of symptoms from observations made in slaughterhouses or livestock markets, follow-up the occurrence and/or spread of an infectious disease based on reporting specific symptoms using official or private veterinary networks.

The strategy for implementing a syndromic surveillance system should target the financial resources, benefits and sustainability of the system. Investment in the surveillance of endemic diseases provides a mechanism for building exactly the core capacities that are likely to enable the detection of emerging infections. It also allows the collection of the baseline surveillance data that are particularly lacking for many developing regions and are crucial in detecting and identify unusual disease events (Halliday et al., 2012).

The components of surveillance systems comprise the priority diseases targeted for surveillance, the structure, core functions, support functions and quality of the system (WHO, 2006). Some of these components are illustrated in table 1.

Table 1 - Components of a syndromic surveillance system (adapted from WHO, 2006).

Components of surveillance and response systems			
System structure	**Surveillance quality**	**Core functions**	**Support functions**
Legislation	Acceptability	Case/Cluster	Standards and guidelines
Surveillance strategy	Timeliness	Detection	Training
Stakeholders	Sensitivity	Registration	Supervision
Networking	Specificity	Reporting	Communication facilities
	Flexibility	Data analysis	Resources
	Simplicity	Feedback	Milestones

To setup a surveillance program, one important first steps is to know the existing population and to establish which syndromes are important to detect, based on clinical signs. Despite of the fact that many zoonoses could be transmitted to humans, their health and socio-economic impact not always justifies its integration in this type of program (Schmidt, 2009). Therefore, previous epidemiological knowledge is important to base the decision to setup a syndromic surveillance program.

Data collection is also a challenge due to the lack of personnel and communication technology in these settings. The majority of the government public services work without or with a low number of computers and the internet service is not available in many places (Chretien et al., 2008). New mobile-phone-based data transmission is a methodology with potential advantage in African countries (Aanensen, Huntley, Feil, al-Own & Spratt, 2009), allowing to collect data through not only voice services, but also, text messages as well as using cell phone applications (Ernest, 2013). However, it is important to assess the flexibility of data input interface, how the database is structured and what can be achieved with the data afterwards. These three main criteria must be taken into account.

After data collection, several statistical analysis are performed in order to define which syndromic surveillance algorithm should be chosen and included in the system to provide an outbreak free baseline (Dórea et al., 2012). Several syndromic surveillance algorithms have been developed in recent years for early detection of disease outbreaks in human and animal populations, including control-chart (Hutwagner, Thompson, Seeman & Treadwell, 2003), moving averages (Miller et al., 2004), and exponentially weighted moving average (Wagner, Moore & Aryel, 2006). As next step, the system must be validated by process indicators or by measuring the ability to detect some more common clusters (Guasticchi et al., 2009).

During system implementation, results from data analysis should be provided through automatised process in real time to all stakeholders. The data quality and timeliness are essential to ensure decisions success to prevent the diseases spread (Nsubuga et al., 2006).

2.5. Previous studies to estimate and characterise dog and cat population

There are very few studies of dog and cat population sizes reported in the last decades. These studies tend to mainly focus on stray dog population estimates for Africa and Asia (Knobel et al., 2005) since rabies remains an important disease in these continents. The majority of these studies focused on estimating dog:human ratio and dog density (per km^2) to extrapolate the total population for urban and rural areas.

Perry (1993) calculated the dog population sizes of Kenya, Tanzania and Malawi in 1990, using projected human population figures of the World Bank 1986.

The most comprehensive study to date of dog population size at a national level in Africa was carried out by Brooks (1990). A full national dog census was conducted in Zimbabwe in 1986 to determine the size and structure of the national dog population and its level of rabies vaccination. There was an average of 0.91 dogs per household in Zimbabwe giving an extrapolated total population of 1,308,577 dogs. In 1994, a household questionnaire survey was conducted by Butler & Bingham (2000) to provide baseline data on the demography and dog-human relationship of the dogs in the communal lands in the same country. A household questionnaire was designed in accordance with the guidelines of WHO & WSPA (1990). The total dog population was estimated to be 1.36 million dogs in communal lands. The survey showed that all the dogs were owned, there was no evidence of a feral population and the correlation between dogs per capita in each communal land and human population density was not significant (Butler & Bingham, 2000).

In Kenya, Perry, Kyendo, Mbugua, Price & Varma (1995) used a visual capture/recapture method to estimate the dog population size in a suburb of Nairobi. During a rabies vaccination campaign, vaccinated dogs were fitted with a nylon collar. One week later, a team observed and counted collared and non-collared dogs in the same study area. Using the Lincoln index method, the dog population was estimated to be within the range 580-635 (with 95% confidence), and the vaccination coverage was 68-75%.

Further sub-national level studies were carried out in Kenya (Kitala, McDermott, Kyule, Gathuma & Perry, 2001), Zambia (De Balogh, Wandeler & Meslin, 1993), Tanzania (Knobel, Laurenson, Kazwala, Boden & Cleaveland, 2008; Kaare et al., 2009) and Chad (Mindekem, Kayali,Yemadji, Ndoutamia & Zinsstag, 2005).

In Asia, several studies were conducted in India (Sudarshan et al., 2006), Thailand (Kongkaew, Coleman, Pfeiffer, Antarasena & Thiptara, 2004), Philippines (Robinson, Miranda, Miranda & Childs, 1996) and China (Knobel et al., 2005) on estimating dog populations.

Several authors carried out surveys in the American continent. These include Mexico (Fishbein et al., 1992; Flores- Ibarra & Estrella-Valenzuela, 2004), Bolivia (Suzuki et al., 2008) and Equator (Beran & Frith, 1988).

More recently, a study was carried out in the non-metropolitan regions of the State of São Paulo, Brazil, by Alves et al. (2005). Forty-one municipalities and 100 census tracts were surveyed. These were selected by a two-stage probabilistic stratified cluster sampling. The strata were formed by grouping the municipalities according to their population size and living conditions. The estimate of the canine population was done including two stages: a visit to homes to apply the questionnaire and deliver collars for people identify their dogs, and counting dogs on the streets.

In Europe, Font (1987) investigated different aspects of stray dog population ecology in Valencia, Spain. Data on the number of free roaming dogs, their location, gender and approximate age were collected during periodic censuses done along seven fixed transects scattered throughout the city. Each transect was run for a number of consecutive days using a small motorcycle. The transects encompassed a variety of urban environments from low income, economically depressed neighbourhoods to middle class, mostly residential, areas. Abundance was estimated using the photographic mark-recapture method (Beck's method).

Asher et al. (2011) evaluated the potential of a variety of sources for estimation and monitoring of the companion dog population in the United Kingdom. A public survey and subpopulation estimates from veterinary practices, pet insurance companies and Kennel Club registrations, were combined to generate distinct estimates for owned dog population using a Bayesian approach. The data referenced included information from 1999 and 2009.

Rinzin (2007) presented the analyses of details of dog and cat submissions to the Society for the Prevention of Cruelty to Animals shelter from July 1999 to February 2006, in Wellington Region of New Zealand. The objective was to document the demographic, temporal, and spatial characteristics of the free-roaming and surrendered dog and cat population in the shelter catchment area. This author used GIS (Geographic Information System) software to plot the spatial distribution of the residence of members of the public who submitted animals to the shelter throughout the study period using kernel smoothing techniques. The results evidenced a positive relationship between the number of households submitting animals to the shelter and mesh block level deprivation index.

Through the literature review, only one study was found aiming to estimate cat population. This study was carry out on Marion Island (van Aarde, 1984), an inhabiting subantarctic region, where the reported destruction of bird populations by exotic predators resulted in the initiation of several independent surveys of feral domestic cat *Felis catus* populations.

2.6. Methodologies for estimating animal population size

According to Fei et al. (2012), statistical procedures for wildlife population size estimative have been improved during the last ten years. However, for estimation of dog population size, researchers seem to apply the simple methods recommended by the WHO & WSPA guidelines (1990), which could be also applied for cats. According to these guidelines, the information on dog population is usually obtained by two types of approach. The first one uses techniques adopted from wildlife biology and the second uses questionnaire surveys.

The type of method used depends on the nature of the population under study (Schwarz & Seber, 1999). Several surveys were accomplished using and combining a variety of techniques in several countries worldwide.

2.6.1. Techniques to estimate animal population size

The estimation of population size is not a simple task. Some efforts are required if reliable information is necessary (WHO & WSPA, 1990; Abbas, 2011; Fei, Chiang, Fei, Chou & Tung, 2012). Sometimes, it is necessary to consider using more than one methodology for the estimation. A total or direct count is the simplest method, but its application is restricted due to its high costs. The recommended capture and recapture rates may require the use of photographic equipment. If a vaccination campaign is already in progress in the area, it is possible to apply a mark-recapture technique (WHO & WSPA, 1990; Alves, Matos, Reichmann & Dominguez, 2005).

The techniques recommended by WHO & WSPA for estimating the numbers of free-roaming carnivores are described in the next paragraphs.

Total or direct counts

With this technique, the observant makes direct visual counts of individual dogs in a defined geographical area within a limited period of time. Counts made in selected regions are combined to estimate the total number of animals roaming on public property and will allow to calculate statistics such as animals density per area (WSPA, 2007).

This methodology could be applied in small communities and rural situations where dog populations are small, but they are not practical over large geographical areas, like in major cities (WHO & WSPA, 1990).

Estimates from rate of capture

To apply this technique, it is assumed that the animal population is closed and the intensities of capture effort and the probability of capture are equal. A closed population is defined as remaining effectively unchanged during the investigation, non-considering processes as birth, death and migration (Swarz & Seber, 1999).

Graphical plotting either the sum of daily captures, the cumulative sum of captures (smoothed and/or extrapolated) can be used to provide estimates of the animal population. One example is to plot the daily number of dogs marked against the accumulated total of marked dogs for each day (WHO & WSPA, 1990).

Estimates from recaptures

This methodology is commonly known as the "Peterson-Jackson" or "Lincoln Index" and is based on the use of a simple ratio obtained by capturing a number of individuals, marking or tagging them, and releasing them back into the population. The population is afterwards sampled again by trapping or field observations and the total number of dogs caught/observed and the numbers that are marked are determined. It is possible to take advantage of vaccination or drug administration campaigns to mark animals. Then the proportion of marked animals registered during repeated observations in the campaign area can be used to calculate the total population size by applying one of both formulas below. The visibility of marked (treated) animals must be equal to the rest of the population during the re-observation period (WHO & WSPA, 1990).

The population estimate is then obtained as follows:

$$\text{Dog population estimate} = \frac{\text{T x C}}{R}$$

where T represents the number of dogs caught, marked and released; C denotes the number of dogs subsequently caught; and R is the number of marked dogs recaptured.

Estimates from photographic recaptures (Beck´s method)

If animals are individually distinguishable, it is not necessary to apply capture, mark and recaptures techniques. The appearance of animals is so variable and unique characteristics can favour this sampling approach.

Photographic material can be used in these cases when due to the higher number of animals, it is impossible to remember every single one. To estimate the total population (N), the next formula is used:

$$N = \frac{Mn}{m}$$

where M is the number of individually identifiable animals for the first time by some method; n is the total number of animals observed during the second time and m represents the number of animals observed again (i.e. recognized by identifying marks).

Usually, employing multiple observation techniques is better, in order to reduce the sampling errors. The study area can be surveyed each day, by walking or using one vehicle, and photograph every observed animal.

The data can be tabulated and the total population estimated (N) using the following formula:

$$N = \frac{\sum(Mn)}{\sum m}$$

where M represents the number of individually identifiable animals observed during the first time by some method, n is the total number of animals observed during the second time, m is the number of animals observed again (i.e. recognized by identifying marks), $\sum(Mn)$ represents the sum of Mn to that point in time and $\sum m$ is the summation of m to that point in time.

Fei et al. (2012) concluded that Beck's method performs fairly well and can be safely used to get a quick population estimate, as long as the underlying assumptions are not severely violated.

2.6.2. Questionnaire surveys

Comprehensive guidelines for the elaboration of questionnaires and their use in surveys are described by WSPA in “Surveying roaming dog populations: guidelines on methodology” (2007).

Questionnaires for gathering population data and for assessing human attitudes toward animals have to be designed very carefully in order to get interpretable answers and to minimize ambiguity. Indeed, questions should be formulated so that people are not tempted to answer what they think the interviewer would like to hear (WHO & WSPA, 1990).

It is important being aware of the fact that all information collected by questionnaire relates only to the “owned” segment of animal population (WSPA, 2007).

The following information is recommended by WHO & WSPA (1990) to be gathered during the survey:

1. Total number of owned dogs (dogs per household, dog:human ratio);
2. Reasons for keeping dogs;
3. Dog keeping practices (supervision, movement restrictions, feeding, shelter and protection, etc.);
4. Age structure and gender ratio of owned dogs;
5. Reproduction and rearing success of owned dogs (such as age, dependent fecundity and fertility, frequency and incidence of oestrus and gravidity, etc.);
6. Health, diseases and mortality rates of owned dogs; and
7. Acceptability of population and disease control measures.

It is important to mention that there is a distinction between stray and feral dogs when animals are classified according to their degree of restriction and dependence (WHO & WSPA, 1990; WSPA, 2007). The first is used to refer to lost and abandoned companion animals that had been socialized to humans before the free-ranging life, and the latter to those which have lived all their life apart from people. This distinction is important because stray dogs can be relatively easily taken into captivity, whereas feral dogs are more fearful and difficult to keep as pets, and thus are more often captured, spayed or neutered, and released back into the parks, vacant lots, and other hiding places on the margins of human society where they are most commonly found.

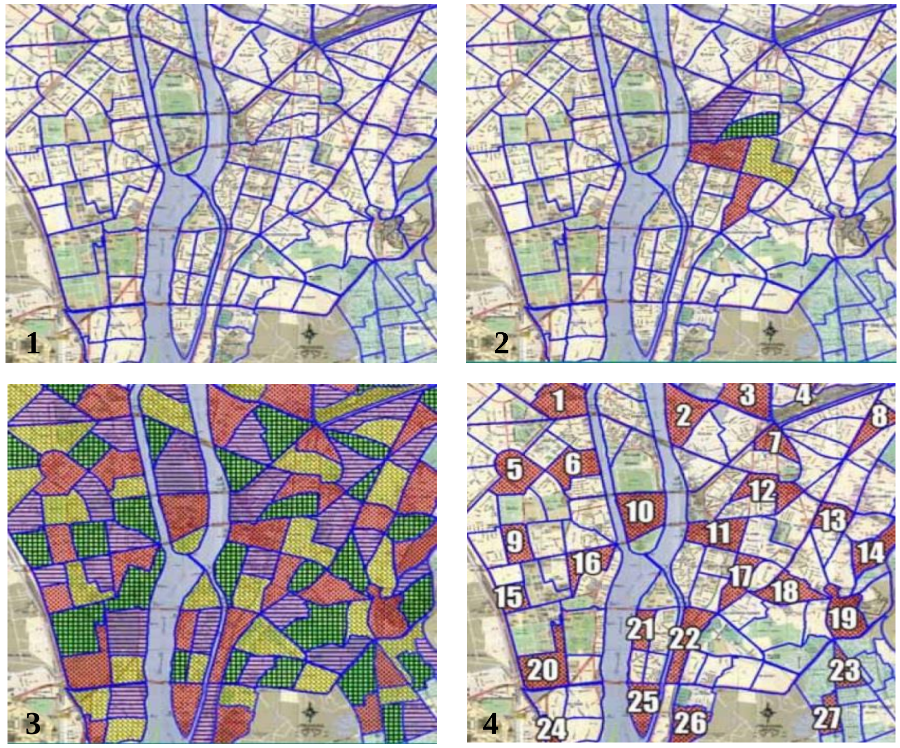
Customary survey methods can be used such as sampling, which has two main types: non-probability and probability sampling. The difference between both is that in the first one, the investigator are able to choose the sample (convenience sampling or purposive selection) and in the second one, the selection of the sample is deliberated, unbiased and each sampling unit in a group has an equal probability of being selected (random sampling) (Thrusfield, 2007). This could be a simple random, systematic sampling, stratified sampling, cluster sampling, post stratification, sized biased sampling and two-stage sampling (Thrusfield, 2007; WSPA, 2007). Other sampling units that can be used are lines to establish transect sampling (by walking, flies by plane or helicopter, or travels by boat down a random line (path) and points (Schwarz & Seber, 1999).

To apply the surveys, it is important to define a representative sample of households. For this, the area covered should be 20-100 km^2, and not less than 100 houses should be investigated (WHO & WSPA, 1990). The households could be chosen by numbering them all and selecting according to random numbers. It might be necessary to select much larger samples, if strong social stratification or several different ethnic or religious groups are obvious in the sampled area. Though, a pragmatic and simple approach to avoid the statistical problem of sampling and possible systematics errors resulting from it could be the inclusion of all households and all animals of a village or township representative for larger areas (WHO & WSPA, 1990).

To select a sample, the city should first be divided into a set of subregions, which cover the entire region of interest and are non-overlapping. One method is to use the smallest local authority defined areas. It is possible to survey other relevant data split by ward such as human population, percentage of main religious types, housing types or services; as these data can be used later to improve the accuracy of the estimate and map the distribution of roaming animal numbers across the city. However, this will require access to maps showing the ward boundaries in sufficient detail to be located by the enumerators. If there are no data available by ward, the wards are too large or there are no adequate maps available showings the boundaries, the entire city region can be split into contiguous subregions using a map that shows the major roads as exemplified in figure 2. The blocks do not need to be the same size and it should take no more than 2 hours to cover (WSPA, 2007). The time required to cover a block will depend on the size, how easy the area is to navigate and how the counting team is travelling (WSPA, 2007).

Tools that can be used to define subregions include remote sensing imagery available through e.g. Google™ Earth (WSPA, 2007) or Open Street Maps™.

Figure 2 - Example of sampling procedures in Central Cairo (adapted from WSPA, 2007).



Legend: The Central Cairo is divided into 108 blocks (1). The blocks are coloured with four colours, beginning at the centre and spiralling outwards, never assigning the same colour to neighbouring blocks (3). Then, one colours is chosen and the blocks with this colour are numbered from left to right and downwards (4).

The number of selected blocks for the sample will depend on the available time and resources. Running test counts in one or two blocks will provide an approximate idea of the time required for the survey. It is important to consider that the higher number of blocks included in the sample, the more accurate the estimate will be. The selection of blocks should be randomly performed so each one has the same chance of being selected. It is important that blocks are well spread across the city or region, rather than being clumped (WSPA, 2007).

This technique is intended to count all the animals that are roaming, not accompanied by an owner on public property at the time of the count.

Despite of the fact that the number of animals will vary during the count, because of animals moving in and out across the block boundaries, it should be possible to get the near to the average number by following guidelines and repeat counts (WSPA, 2007). The agreed protocol should include animals at block boundaries and persons should not try to include an animal by adjusting their speed. The counters need to search for animals in possible hiding places (e.g. under cars, in drains). The counters' movement are important to reduce the number of times that an animal is seen, avoiding double-counting individuals and also should been done by moving quietly and inconspicuously, in order to avoid scaring the animals.

These activities should be performed at dawn (WSPA, 2007) or at twilight, when the streets are not filled with traffic (WSPA, 2007) and the temperatures are pleasant in summer; ensuring that the counter can move easily through the streets and animals are not hiding from high temperatures.

2.6.3. Using remote sensing to estimate animal population

Remote sensing can be defined as the scientific and technical discipline that involves acquiring information of various features from a distance. Sometime the distance is larger, such as for satellite-based remote sensing where the satellites are in orbit high above the Earth's surface; but the distance may also be much shorter, such as for aircraft-based remote sensing where the airplane is much closer to Earth (Schott, 2007; Schowengerdt, 2007).

There are two main types of remote sensing (Liu & Mason, 2009). The first is passive remote sensing where sensors detect natural radiation that is emitted or reflected by the object or surrounding areas. This includes (infrared) photography and the use of radiometers. For the second type, active collection, energy is emitted by a source near the sensor in order to scan objects and areas. Then a sensor detects and measures the radiation that is reflected or backscattered from the target (Liu & Mason, 2009).

Geographic Information System (GIS) can be defined as the technical discipline that uses computer-based (digital) geospatial data to map and model geographic information, allowing the viewing and analysis of multiple layers of spatially related information associated with a geographical location or region.

Since both remote sensing and GIS give information about features on the earth's surface, almost all GIS use remote sensed data for a number of reasons like for a continuous view of the region or extracting any other information.

Traditional methods for estimating animal population most often rely on visual surveys, where animals need to be seen to be counted using methods previously described. These traditional methods have been used in several studies covering every major taxonomic group (Tran et al., 2008). However, they do not work well when animals are inherently hard to see due to several factors such as the habitat, their size or when they're hard to trap. In addition, traditional surveys can be very expensive, requiring trained observers and expensive survey vehicles to operate for extended periods. To overcome these issues, the application of remote sensing techniques for ecological studies has increased in the last decades.

The contribution of remote sensing to the study of ecology in general and to wildlife and ecosystem management in particular, has been demonstrated in several studies. For example, to estimate animal population in data sparse environments such as Antarctica (Fretwell et al., 2012) or Africa (Ndegwa & Murayama, 2009) where remote sensed data was used, making it possible to collect data on hazardous or inaccessible areas. Such studies are becoming more common, due to the availability of low cost GIS software with user-friendly interfaces.

3. Materials and Methods

3.1. Data collection

3.1.1. Demographic data

Census 2010 results (INE, 2012) were used to provide information about the total number of residents, the number of people for each age group and the number of workers in each locality on the island.

Remote sensed imagery obtained from Google^{TM} Earth was used to calculate the number of houses, its localizations and urban areas across the island. The most recent available images were selected in March 2013. These images were taken on February 2nd 2009 (East and North region of the island) and August 10th 2012 (West and South region of the island). The only exception on this was Barreiro, in the West and Wouth region, since visualization of its urban area was impossible due to the cloudy image; an image from February 2nd 2009 was used.

To collect the houses location, each building was “marked” using Google^{TM} Earth imagery and saved as Keyhole Markup Language file format (.kml extension). Then, this file was used in Quantum GIS 1.8 to represent the total number of houses in each village. This program was also used to set polygons representing urban area and subsequently calculate its area size. In two villages, Barreiro (figure 3) and Calheta, the buildings were localised as different clusters. In these cases, a polygon was created for each cluster and the area was calculated based on the sum of the surface area of the different polygons. This unit measure was m^2 since urban areas were reduced in the villages.

Figure 3 - Barreiro urban area delimited with polygons (adapted from Google^{TM} Earth imagery).

Legend: The blue polygons represent the urban area.

3.1.2. Survey of dog and cat population

The data collection was performed in the course of VSF-Portugal mission on the island in the period from October 15th to 24th 2012. The study populations were dogs and cats which owners resided in localities conveniently selected.

According to previous studies and grey documents researched, stray animals were a problem in several islands in Cape Verde. The initial plan for data collection included two approaches. The first involved a visit to houses to apply a questionnaire (Annexes 2 to 5 – Dog and Cat observation registry form). The second was to identify animals on the streets and record animal's gender and age when possible. The coordinates for each animal's location would be recorded using a GPS (Global Positioning System) unit in both cases. Subsequently, the animals would be marked with a colour marker stick in order to avoid double register. All the information would be gathered using the same questionnaire. This strategy would able to include stray animals in the survey. Based on literature reviewed, it was establish that the best time to start the questionnaires was at dawn.

On the first day of the field study, it was not possible to observe and mark animals in Porto Inglês since there were no animals on the streets. After discussing the purpose of this project with the inhabitants, it was clear that the relationship between companion animals and humans was very important. The local residents reported that stray animals were not a problem on this island and, despite the fact that animals have free access to the street, all animals were owned. Other important fact was the close relation between people and community cohesion in this community, allowing to identify the owners of the animals which were on the street. Therefore, the task of marking and identifying animals on the streets was excluded, and the survey was only focused on questionnaires applied to households.

In this project, a pilot study was not planned due to the short period of time for the field work in Maio Island. However, the importance of performing this stage became clear since a second approach was needed in order to adjust the survey to the population characteristics on this island.

The questionnaires were carried out by the author and applied according to tracks previously defined (parallel roads) as exemplified in figure 4.

The questionnaires were applied face-to-face and in Portuguese language to one of the house residents. When it was possible to have eye contact with the animals on the street, it was asked information about their owned status to make sure they were not stray animals.

The questionnaire was composed by open and closed questions. The highly summarized modules enabled to establish the degree of restriction and dependence [according to WHO & WSPA (1990) guidelines], age, gender, sterilization and parasites control status, appearance, skin changes and other observations. Skin changes were included on the survey to evaluate the presence of signs indicating potential zoonoses, such as mange, on the animals. The coordinates of feeding place were recorded for each dog and cat using one GPS unit (Garmin® Etrex 20).

In order to take advantage of the short period of the visits, it was necessary to make a proper time management. The survey was conducted in the morning period in five villages (Alcatraz, Calheta, Figueira da Horta, Morrinho and Morro) since it was the only time whereupon the transportation could be provided by Livestock Services (Agriculture, Forestry and Animal Husbandry services of Cape Verde). The villages were selected based on Livestock Services planned activities on the island.

In Porto Inglês city, the survey was conducted in the afternoon period and the approach was different due to its dimension. First, Porto Inglês was divided into a set of sub-regions (“blocks”) with 200 m size (figure 5) using Quantum-GIS 1.8 software and Google™ Earth imagery. Figure 5 shows how the survey was conducted, where each colour corresponds to a specific date.

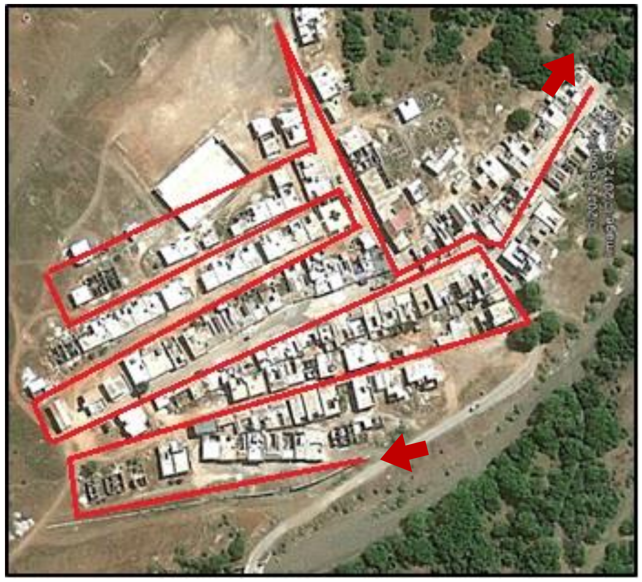
The survey included all the households from the six localities and the response rate was 100%. However, it should be noted that some houses were abandoned or uninhabited. These situations were confirmed by local inhabitants.

3.1.3. Clinical observation of dogs and cats

The data collection was carried out at the same time as the survey of dog and cat population.

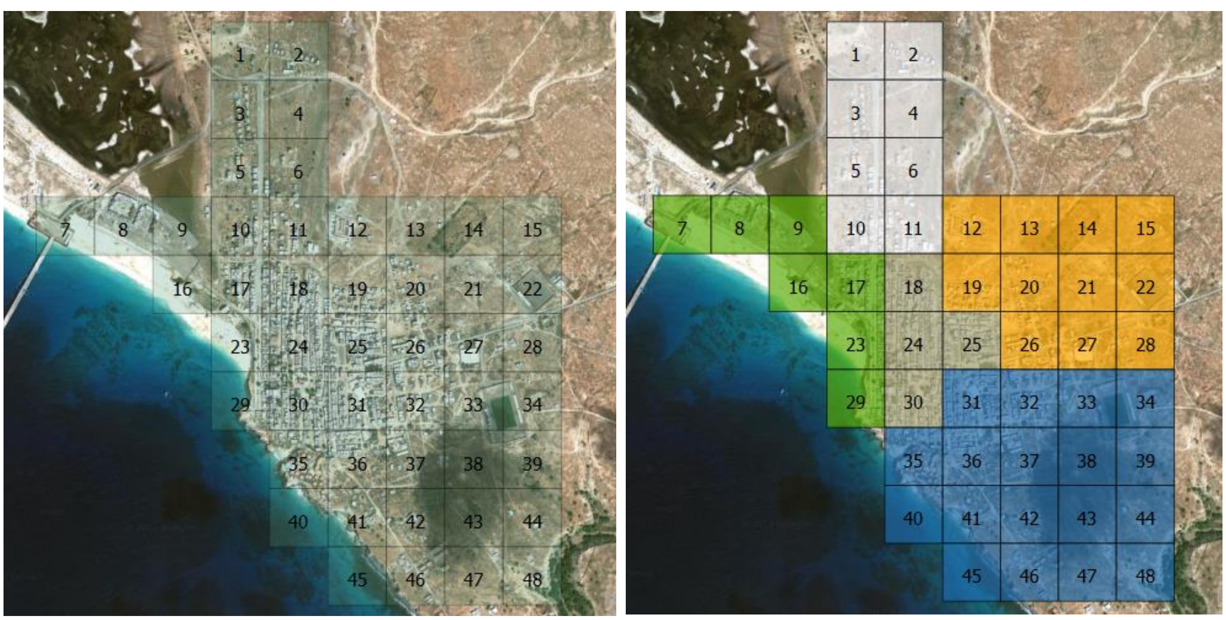
The third questionnaire (Annex 6 and 7 – VSF-Portugal companion animal health and welfare campaign questionnaire) was applied to animal’s owners during the VSF-Portugal campaigns in Porto Inglês. This inquiry form was composted in three main parts: home identification (address, name of the owner), animal identification (specie, gender, age, vaccinations, number of litters during the preceding year for females, etc.) and the clinical file (symptoms, procedures and treatments). It was also included one question about the presence of skin lesions in the animal’s owners indicative of possible zoonoses.

Figure 4 - Tracts used to apply the questionnaires in Figueira da Horta (adapted from Google™ Earth imagery).



Legend: The arrows indicate the beginning and the end of the tract (red line) used to apply the questionnaires in Figueira da Horta.

Figure 5 - Grid map of Porto Inglês used to apply the questionnaire (adapted from Google™ Earth imagery).



Legend: Porto Inglês divided in 48 blocks with 200 m size. The white indicates the block where the questionnaires were applied on October 17th; the yellow corresponds on October 18th; the green corresponds on October 19th, the brown relates on October 20th and finally, the blue tallies on October 21st.

3.2. Data processing and analysis

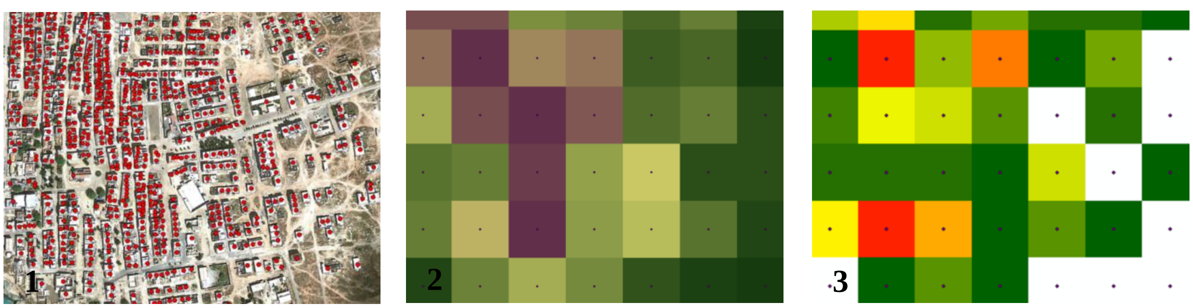
3.2.1. Demographic data

Census 2010 results were inserted with the number of dog and cat population into an Excel® sheet and the animal:human ratio were calculated for each species. R 2.15.2 statistical programming environment (R Development Core Team 2012) were used to assessed if there is any correlation between the number of animals and the total resident population, by age categories and the number of workers for each visited locality.

It is known that dogs and cats are kept by most people in African countries, whom provide food and shelters, contributing for their subsistence. Based on this assumption, it was decided that animal populations would be estimated based on the number of houses as predictor variable.

The number of buildings calculated based on Google™ Earth images, was used as a proxy of the number of households. A shapefile (.shp extension) was created with house locations using the ArcGIS® 10.1 software. Next, a grid with 20 km size layout was created to cover all island surface. Each cell equalled 100 m a side, corresponding to an area of 1 ha. As a third step, the Spatial Analyst extension was used to calculate house density per ha for all localities across the island and a raster file was created with these values (figure 6).

Figure 6 - Spatial data processing workflow (adapted from Google ™ earth imagery).



Legend: Digitized house in Porto Inglês (1). Each red point represents one house. As second step, a grid was created and the number of houses was calculated per pixel (1 pixel= 1 ha). Different colours represent different house densities and the points represent the polygons centre (2). A raster file was created with the house density (3).

3.2.2. Survey of dog and cat population

The collected data on restriction and dependence, age, gender, sterilization and parasites control status, appearance and skin changes was inserted into an Excel® sheet and descriptive statistics were obtained using R 2.15.2 statistical programming environment (R Development Core Team 2012).

A shapefile (.shp extension) was created for both species with the coordinates of feeding places using the ArcGIS® 10.1 software.

The next step were to calculate dog and cat densities per ha for the visited localities using the same methodology previously described for house density calculation. As final step, Albers Equal Area Conic projection was used for these rasters as it uses two standard parallels to reduce some of the distortion for small regions.

3.2.3. Spatial data

In order to assess the resolution impact on predictive models, several spatial aggregations were performed to create new rasters files with different resolutions for dog, cat (survey dog and cat population) and house densities (demographic data). Each output cell contained the sum of the input cells that are covered by the extent of the output cell (figure 7). With this function, each side of the output pixels will measure 100 m multiplied by the factor (F) number (table 2).

As mentioned before, the total grid size was 20 km. In order to avoid any disparity on the rasters extension, it was decided to use Factor 2 (F2), Factor 4 (F4), Factor 5 (F5), Factor 8 (F8) and Factor 10 (F10) to create new rasters.

A total of 18 raster files with dog, cat and house densities on different resolutions were imported into the R environment using the raster and rgdal packages.

Given the fact that the grid covered all island, the first step was to classify the pixels with value 0 as NA (non-value) in order to mask areas with no houses and no animals to build the model.

As next step, the preliminary analysis was performed and involved plotting data using box-and-whiskers plots, scatterplots and mapping of dog and cat population. The first graphs provide a good overview of the data distribution showing dispersion, skewness and long drawn out tails.

Figure 7 - Illustration of a raster spatial aggregation process based on the largest value of the input cells (maximum value) (adapted from http://help.arcgis.com/en/arcgisdesktop/10.0/help/).

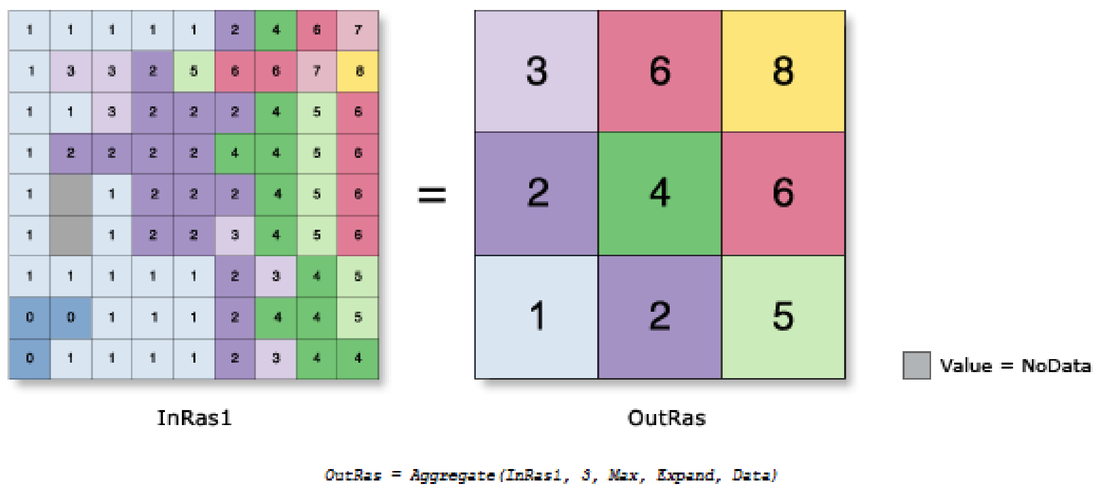


Table 2 - Factor and corresponding pixel size.

Factor	**Pixel size (m)**
F1 (original grid)	100 x 100
F2	200 x 200
F4	400 x 400
F5	500 x 500
F8	800 x 800
F10	1000 x 1000

In order to measure the strength of the relationship between dog, cat and house densities, the Spearman's Rank Correlation Coefficients were also calculated for the different F.

Based on Spearman's Rank Correlation Coefficients, it was decided to build models for aggregation factors F2 and F4 due to the high correlations between variables and spatial accuracy to locate animal densities across the island.

Four simple linear regression models were created based on the least squares regression line and the number of houses was defined as the only predictor variable.

Statistical methodologies were used to validate and help decide upon a final regression model, and also to determine how well the models performed in practice. This task included coefficient of determination (R^2) used to determine the likelihood of future events falling within the predicted outcomes and residuals vs fitted plots to assess quality of the regression. The residuals were mapped for F2 model (200 m resolution) in order to evaluate their distribution and find the locations of the highest differences between the observed and predicted values.

Furthermore, *K*-fold cross-validation was performed using the Data Analysis and Graphing (DAAG) package for R program and 3 subsets (K=3) were defined in order to assess the models over-fitness.

The last approach to evaluate both models was comparing the total number of dogs and cats identified in the survey with predicted value from both models for the six visited localities.

3.2.4. Clinical observation of dogs and cats

The results of the VSF – Portugal campaign questionnaires were inserted into an Excel® sheet and descriptive statistical analysis was performed, providing simple summaries about the data collected.

3.2.5. Comparison of results obtained during the clinical exam and on the survey of dog and cat population

In order to compare the results from the survey of dog and cat population and VSF-Portugal database, significant differences between proportions of gender, sterilization, degree of dependence and skin changes were tested, using hypothesis testing for single proportions (Petrie & Watson, 2001). In this test, proportions obtained in VSF data were compared with the population proportions obtained in the field survey. Some variables were collected in different way and therefore needed to be summarized, as in the case of habitat and skin changes. For the habitat it was establish that the first group (restricted supervision) included the number of animals living inside home and at the backyard; the second group included animals with limited access to the street; and the third group included animals with free access to the street and living on the street. This last group is similar to neighbourhood and feral groups included on the survey of the dog and cat population.

4. Results

4.1. Demographic data results

According to Census 2010 (INE, 2012), the localities with the highest and lowest population are Porto Inglês and Alcatraz respectively (table 3).

Based on Google™ Earth imagery, the locality with the highest area is Porto Inglês (1624238 m^2) and the lowest is Alcatraz (22189 m^2).

Table 3 - Human population and area for sampled localities.

	Human Population							
			Age					
Localities	Gender	Resident population	< 15 years old	15-64 years old	>65 years old	Working (≥15 years old)	Area (m^2)
Alcatraz	Total	232	72	144	16	84	22189
	Male	117	40	69	8	58	
	Female	115	32	75	8	26	
Calheta	Total	1156	375	686	93	512	184140
	Male	568	193	341	33	282	
	Female	588	182	345	60	230	
Porto Inglês	Total	2971	928	1855	184	1412	1624238
	Male	1417	461	888	64	744	
	Female	1554	467	967	120	668	
Figueira da Horta	Total	446	121	147	252	47	56907
	Male	221	147	252	47	184	
	Female	225	75	124	22	107	
Morrinho	Total	444	139	269	36	210	60461
	Male	215	64	131	20	117	
	Female	229	75	138	16	93	
Morro	Total	310	92	181	37	159	71325
	Male	157	44	101	12	95	
	Female	153	48	80	25	64	

Based on Google™ Earth imagery, a total of 2485 houses were identified and digitized on the island. The locality with the highest number of houses was Porto Inglês (1195 houses) and the lowest number of houses was found in Monte Farenegro (1 house) (table 4).

Table 4 - Total number of houses on the island.

Localities	**Total number of houses**
Alcatraz	70
Barreiro	176
Calheta	290
Cascabulho	75
Porto Inglês	1195
Figueira da Horta	171
Figueira Seca	31
Morrinho	131
Morro	121
Pedro Vaz	69
Pilão Cao	46
Praia Goncalo	29
Ribeira D João	70
Sto António	10
Monte Farenegro	1
Total	**2485**

4.2. Survey of dog and cat population

4.2.1. General analysis

Characterization of size, gender, sterilization and deworming status

All households in the six localities were visited by the author and the total number of animals was 457 dogs and 306 cats. Males were more frequent than females but in general, in this gender they had smaller proportions of dewormed or spared animals.

According to tables 5 and 6, Porto Inglês is the locality with the highest number of animals (272 dogs and 156 cats) and also with the highest percentage of sterilized and dewormed animals. Results show that for both species, females (23.63% of female dogs and 16.90% of female cats) are sterilized dewormed in a higher percentage than males. The percentage of dewormed animals is also higher in females for both species (30.71 % of female dogs and 16.90% of female cats).

Age and degree of restriction

Table 7 shows that Figueira da Horta is the village where exist a larger percentage of young (4/27*100=18.52%) and juvenile (16/27*100=59.26%) dogs can be found in contrast with Morrinho where the percentage of adult dog (22/34*100=64.71%) respectively is higher at the village level. Calheta has the highest percentage (2/72*100=2.78%) of older dogs.

The main age group for cats vary according to the village. Alcatraz (3/5*100= 60.00%), Morro (8/14*100= 57.14%) and Calheta (26/63*100= 41.27%) were the villages with the highest percentage of young, juvenile and adult cats, respectively. Porto Inglês was the only locality with 2 cats older than 7 years old.

At the island level, the age group with higher number of dogs is between 2 and 7 years old (40.48%) in contrast with cats, which is from 6 months to 2 years old (45.8%).

The results also indicated that the majority of dogs and cats are classified as restricted or supervised animals (59.3% and 60.46% respectively) and as family animal (38.73% and 36.93% respectively). Porto Inglês was the only locality where feral and neighbour animals were reported for both species.

At the village level, Morrinho and Figueira da Horta had the highest number of cats (22/26*100=84.62 %) and dogs (23/27*100=85.19%) which were classified as restricted or supervised.

Table 5 - Dog population characterisation: gender, sterilization and parasite control.

Localities	Total	Female	Sterilized	Pregnant	Dewormed	Male	Sterilized	Dewormed
Alcatraz	12	7	0	0	0	5	0	0
Calheta	72	28	0	1	7	44	0	9
Figueira da horta	27	7	0	0	0	20	0	0
Morrinho	34	14	0	1	1	20	0	1
Morro	40	15	2	2	2	25	2	8
Porto inglês	272	111	41	3	46	161	45	45
Total	457	182	43	7	56	275	47	63
Total %		39.82	23.63	3.85	30.71	60.18	17.09	22.91

Table 6 - Cat population characterisation: gender, sterilization and parasite control.

Localities	Total	Female	Sterilized	Pregnant	Dewormed	Male	Sterilized	Dewormed
Alcatraz	5	3	0	0	0	2	0	0
Calheta	63	21	0	0	0	39	0	2
Figueira da horta	42	15	0	0	2	27	0	0
Morrinho	26	16	0	0	0	10	0	1
Morro	14	8	0	1	0	6	0	0
Porto inglês	156	79	24	1	22	73	18	22
Total	306	142	24	2	24	157	18	25
Total %		46.41	16.90	1.41	16.90	51.31	11.46	15.92

Body condition and skin changes

The total number of dogs and cats were classified as having normal body condition. Only one male dog was reported has having skin changes, which included alopecia, crust and peeling.

Table 7 - Dog and cat population characterisation: age and degree of restriction.

	Dog								***Cat***							
	Age				**Degree of restriction and dependence**				**Age**				**Degree of restriction and dependence**			
Localities	Y	J	A	O	1	2	3	4	Y	J	A	O	1	2	3	4
Alcatraz	2	7	3	0	6	6	0	0	3	2	0	0	2	3	0	0
Calheta	13	25	32	2	36	36	0	0	10	31	26	0	33	30	0	0
Figueira da horta	5	16	6	0	23	4	0	0	15	16	11	0	35	7	0	0
Morrinho	5	7	22	0	13	21	0	0	9	7	10	0	22	4	0	0
Morro	7	14	19	0	24	16	0	0	4	8	2	0	6	8	0	0
Porto inglês	57	105	103	7	169	94	4	5	20	76	54	2	87	61	7	1
Total	89	174	185	9	271	177	4	5	61	140	103	2	185	113	7	1
Total %	19.47	38.07	40.48	1.97	59.30	38.73	0.88	1.09	19.93	45.80	33.66	0.65	60.46	36.93	2.29	0.33

Legend**:** Age: Young (≤6 months), Juvenile (>6 months, ≤2 years old); Adult (>2 years, ≤ 7 years), Older (> 7 years); Degree of restriction and dependence 1- Restricted or supervised (Fully dependent and fully restricted or supervised) 2- Family (Fully dependent; semi-restricted) 3- Neighbourhood (Semi-dependent; semi-restricted) 4- Feral Independent, unrestricted (Although they may survive on human waste material nobody will take responsibility for them).

4.2.2. Relation between dog and cat population and demographic data

Animals densities and ratio between habitants, age groups and workers

A total of 457 dogs and 306 cats were identified on the six localities; 514 households were identified as owning a dog and/or cat, which demonstrated that 26% (514/1978*100) of the houses had, at least, one animal.
Results in table 8 show that the average number of animals per house is higher for dogs in Morro (0.33) and for cats in Figueira da Horta (0.25). The lower values for dogs are in Figueira da Horta (0.16) and for cats in Alcatraz (0.07).

Table 8 - Number of households with dogs and cats in the sampled localities.

Localities	Nr of Houses[1]	Nr of dogs	Nr of cats	Houses with dogs	Houses with cats	Houses with both species	Nr of dogs per house	Nr of cats per house
Alcatraz	70	12	5	12	5	2	0.17	0.07
Calheta	290	72	63	49	40	18	0.25	0.22
Figueira da Horta	171	27	42	21	34	4	0.16	0.25
Morrinho	131	34	26	24	17	10	0.26	0.20
Morro	121	40	14	24	14	10	0.33	0.12
Porto Inglês	1195	272	156	288	160	105	0.24	0.13
Total	1978	457	306	418	270	149	1.09	1.13

As the results show (table 9), the dog density (per m^2) is higher than the cat density (table 10) in all localities, except in Figueira da Horta. The dog density is the highest in Morrinho and Morro (0.0006) and the ratio number of dogs:habitant is the highest in Morro (1:7.75). The dog/ habitant≥15 and < 64 years old ratio is the highest in Morro and for dog/worker ratio is in Figueira da Horta.
As can be seen in table 10, the ratio cat:habitant is the highest in Figueira da Horta (1:10.62). The ratio animal/worker is the highest in Figueira da Horta and the lowest in Alcatraz for both species and also in Calheta for dogs. For both species, the ratio between the number of animals:age category is the highest for the category ≥65 years old and the lowest for people from 15 until 64 years old, except for Figueira da Horta.

[1] Estimated based on Google™ Earth images.

Table 9 - Dog population density and ratio between habitats, group ages and workers.

Localities	Dog/m^2	Dog:Habitant	Dog/hab < 15 years old	Dog/hab ≥15 to 64 years old	Dog/hab ≥65 years old	Dog/worker[2]
Alcatraz	0.0005	1:19.33	0.16	0.08	0.75	0.14
Calheta	0.0004	1:16.06	0.19	0.10	0.77	0.14
Figueira da Horta	0.0005	1:16.52	0.22	0.18	0.11	0.57
Morrinho	0.0006	1:13.06	0.24	0.13	0.94	0.16
Morro	0.0006	1:7.75	0.43	0.22	1.08	0.25
Porto Inglês	0.0002	1:10.92	0.30	0.15	1.53	0.19
Total	0.0003	1:12.16	0.27	0.14	0.74	0.19

Table 10 - Cat population density and ratio between habitats, group ages and workers.

Localities	Cat/ m^2	Cat:Habitant	Cat/hab < 15 year old	Cat/hab ≥15 to 64 year old	Cat/hab ≥65 year old	Cat/worker[2]
Alcatraz	0.0002	1:46.4	0.07	0.03	0.31	0.06
Calheta	0.0003	1:18.35	0.0003	0.17	0.09	0.68
Figueira da Horta	0.0007	1:10.62	0.35	0.29	0.16	0.89
Morrinho	0.0004	1:17.08	0.19	0.10	0.72	0.12
Morro	0.0002	1:22.14	0.15	0.08	0.38	0.09
Porto Inglês	0.0001	1:19.04	0.17	0.08	0.85	0.11
Total	0.0002	1:18.17	0.18	0.09	0.50	0.13

[2] Workers with > 15 year old.

Correlation between population groups

As it can be seen in table 11, the correlation between demographic variables and the number of animals is significantly high for all variables, ranging from 0.85 to 0.99.

Table 11 - Pearson correlation matrix between variables.

	Population Resident	***Population ≤15 year old***	***Population >15 to ≤ 64 year old***	***Population ≥ 65 year old***	***Workers (≥15 year old)***	***Dog population***	***Cat population***
Population Resident	1.00	-	-	-	-	-	-
Population ≤15 years old	0.99	1.00	-	-	-	-	-
Population >15 to ≤ 64 years old	0.99	0.99	1.00	-	-	-	-
Population ≥65 years old	0.88	0.88	0.86	1.00	-	-	-
Workers (≥15 years old)	0.99	0.99	0.99	0.85	1.00	-	-
Dog population	0.99	0.99	0.99	0.87	0.99	1.00	-
Cat population	0.99	0.99	0.99	0.92	0.99	0.98	1.00

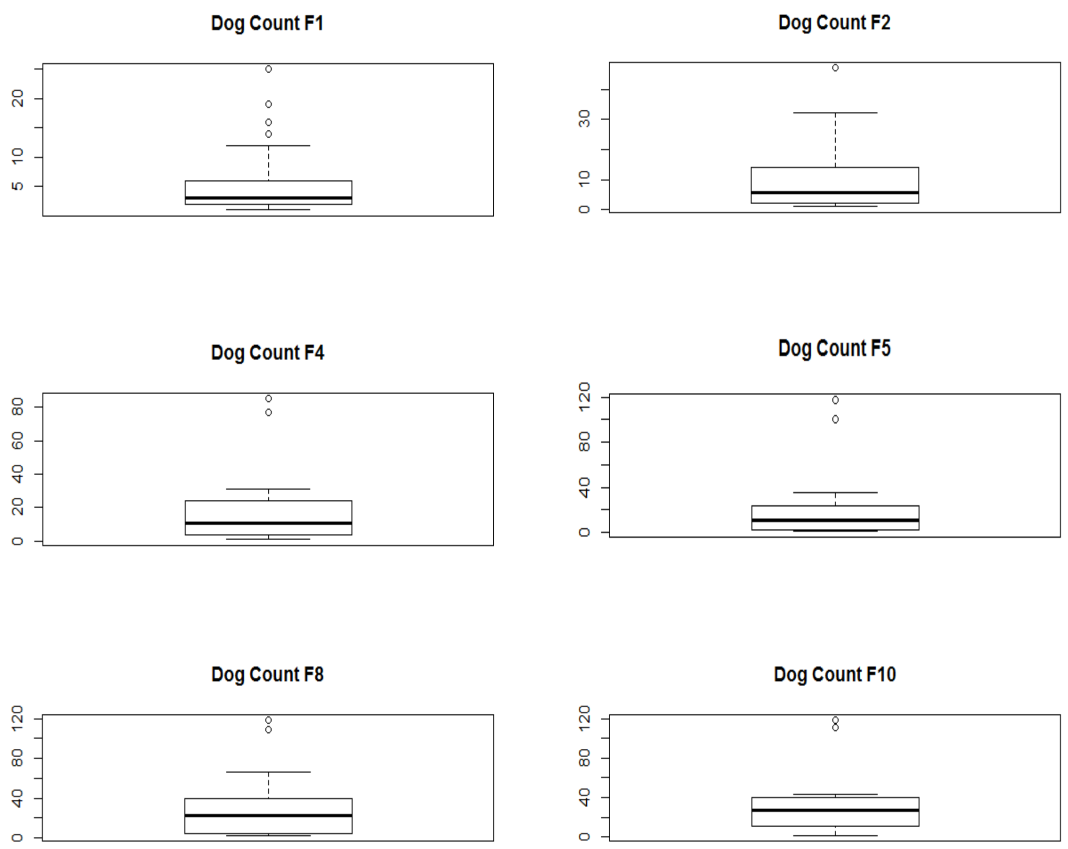
4.2.3. Spatial analysis of the dog and cat population

Distribution of dog densities

The plots for the different F reveal a positive skewness (figure 8). In order words, it shows a majority of values near the lower end and the "tail" of the distribution is more stretched at the higher end. As it was expected, as long as the pixel size increases, the mean and the maximum values also increased, since the aggregation was performed using a sum function.

It could be noticed that the number of outliers decreased between F1 and F2, since the data was aggregated. The most important fact is the skewness reduction as the pixel size increase.

Figure 8 - Box-and-whiskers plots for dog count for F1, F2, F4, F5, F8 and F10.



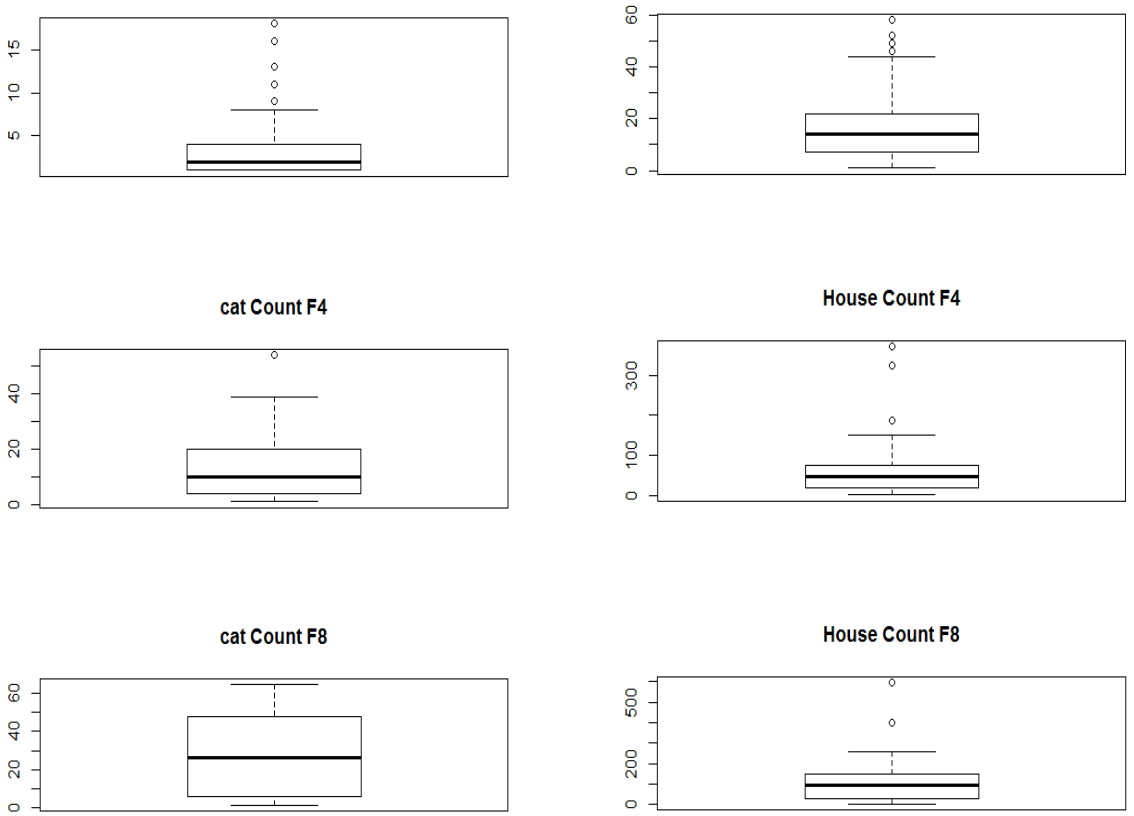
Distribution of cat and house densities

For cat and house densities, the conclusions are the same as for dog density. Figure 9 shows the results for both variables using F1, F4 and F8.

Both variables have a positive skewness. As pixels size increase, the animal and house counts increase as well.

Results evidence the presence of outliers for the different resolutions. This could be explained by the fact that Porto Inglês have some areas (mainly in the village centre) where the house density is very high. The maximum value of house density increases 10 times, from 60 to 600 houses per pixel, using 800 m for the pixel size.

Figure 9 - Box-and-whiskers plots for cats and house densities for F1, F4 and F8.



Mapping of dog and cat population

It can be seen that, for both species, the highest density values are observed in the same region (pixel) (figures 10 and 11). This pixel represents the centre of Porto Inglês. For surrounding areas, animal densities are lower and there is no pattern in animal's distribution. Figure 11 also demonstrates that in north, there is an area where the density of cats is higher.

Figure 10 - Dog density distribution in Porto Inglês.

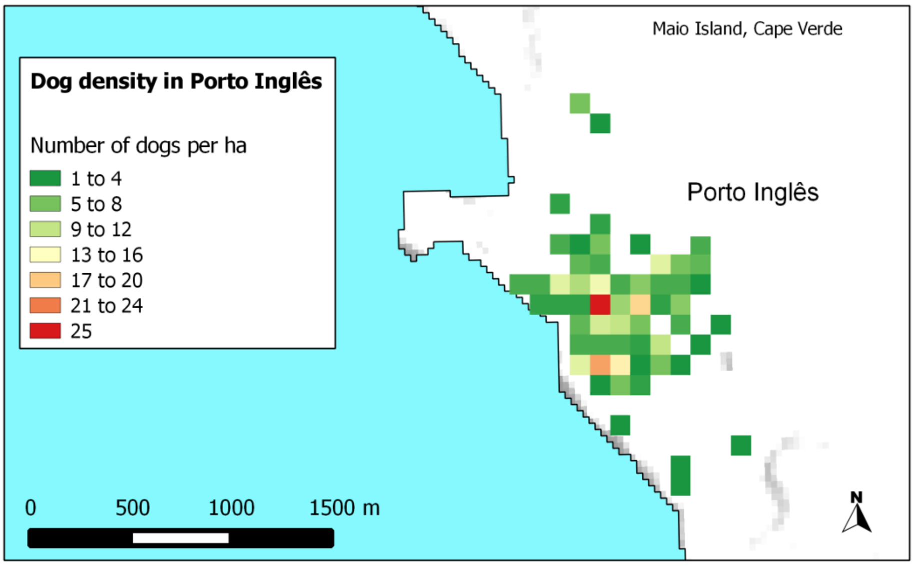
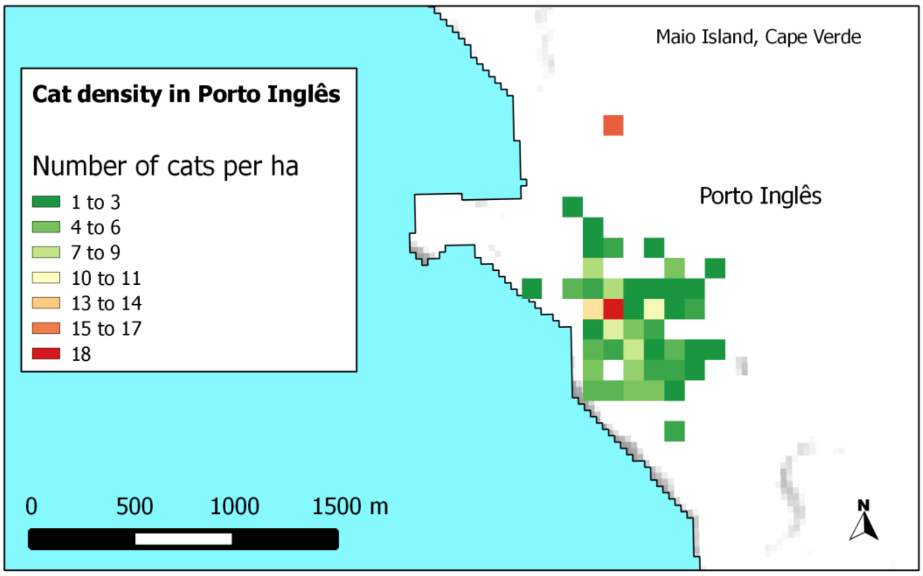


Figure 11 - Cat density distribution in Porto Inglês.

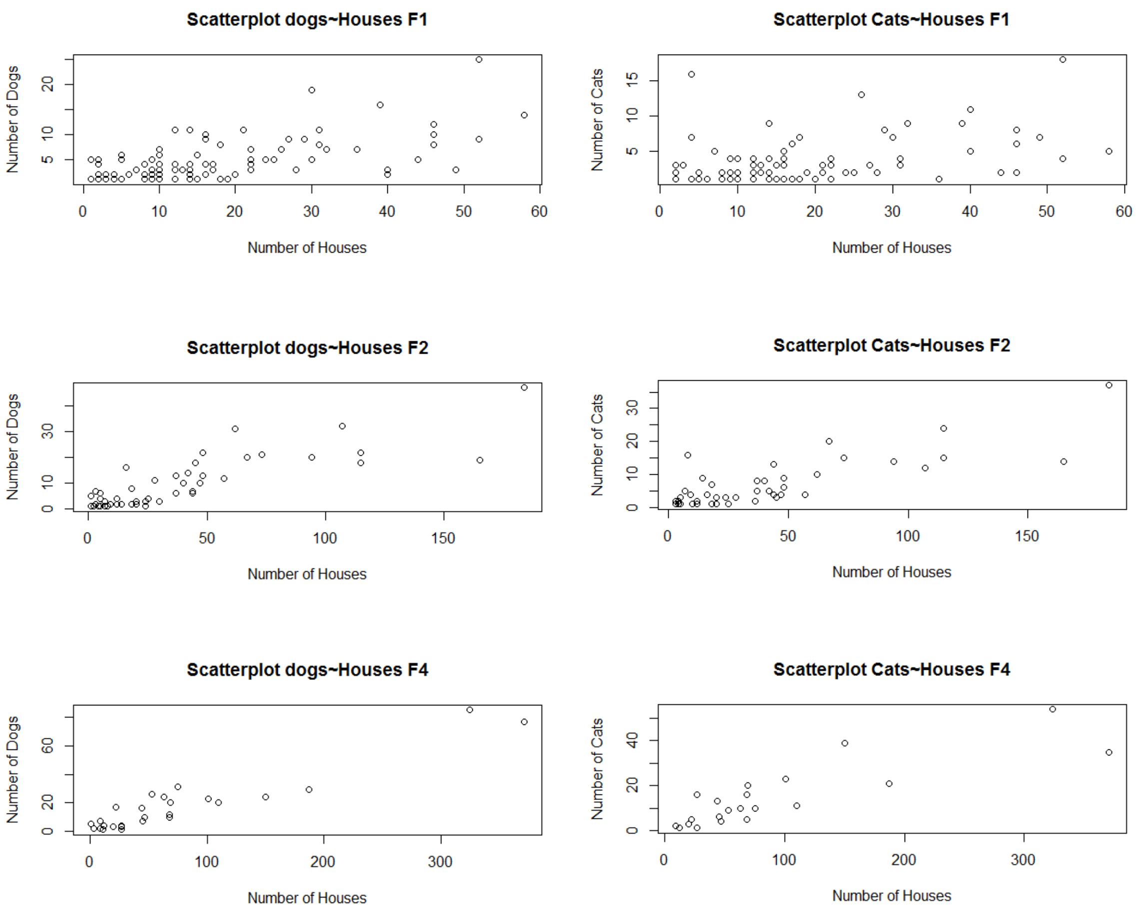


Assessment of linear relationship between the number of houses and the number of animals

Figure 12 suggests a positive association between animals and house densities. The scatterplots show a weak linear trend for 100 m resolution (F1) for both species, where data has some noise (meaningless). This noise could be defined as the random error or variance in a measured variable. For 200 m (F2) and 400 m (F4) resolutions, this linear trend tends to be stronger.

The scatter-plots show that the noise associated with lower F values, is filtered out as the spatial resolution increases. As long as the pixels are aggregated, the number of pixels will decrease and the covered area will increase since values are attributed to areas near the town's limits were no observations existed. For higher F values, the noise (variance) in data decreases and the association between variables gets stronger.

Figure 12 - Association between variables represented by scatterplots for F1, F2 and F4.



Assessment of the correlation coefficient between the number of houses and the number of animals

Results in tables 12 and 13 show that the correlation between variables increases with spatial aggregation. For the association between dog and house density, the variation of the correlation is more pronounced until F2 and from there on, it changes only slightly. For the association between cat and house density, the correlation coefficient increases until F4 and decrease for F5.

Considering these results, it was decided to build models for aggregation factors F2 and F4 since they represent high correlations and they can provide sufficient spatial detail to locate animal densities across the island.

Table 12 - Association between dog and house densities.

F	Nr of observations	Spearman's Rank Correlation coefficient	p- value
1	102	0.583	1.32E-10
2	50	0.813	7.22E-13
4	26	0.839	8.73E-08
5	22	0.842	9.10E-17
8	14	0.877	3.90E-05
10	13	0.882	6.78E-05

Table 13 - Association between cat and house densities.

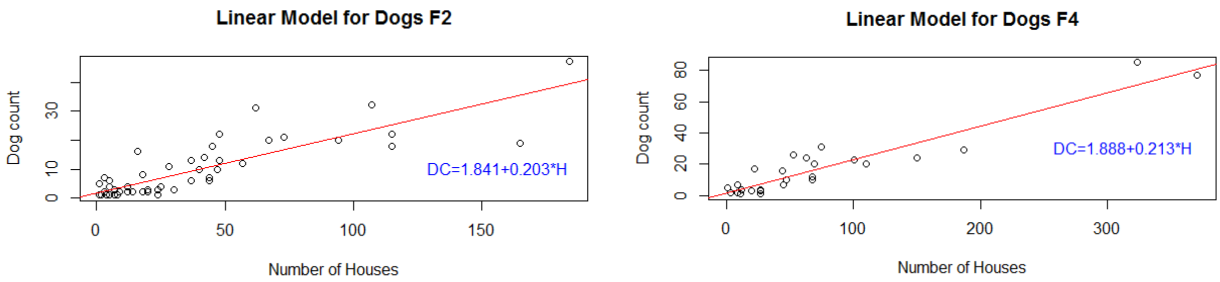
F	Nr of observations	Spearman's Rank Correlation coefficient	p- value
1	91	0.439	1.35E-05
2	44	0.705	9.11E-08
4	22	0.826	2.18E-06
5	18	0.768	1.98E-04
8	11	0.955	2.20E-16
10	11	0.945	2.20E-16

4.2.4. Population size estimative model

4.2.4.1. **Dog Model**

The linear models created to estimate dog population size (figure 13) show that the slope value (0.2) is practically the same for both models, which means that the results of these two models will not be very different. This can be interpreted as the expected change in dog count for one-unit change in the number of houses.

Figure 13 - F2 and F4 linear regression models for estimating the dog population.



4.2.4.1.1. Model evaluation

Coefficient of Determination (R^2)

Results revealed that R^2 is higher for the model built with 400 m pixel size (R^2 =0.89) than for the 200 m model (R^2 =0.72).

For F4 model it may be interpreted as follows: "Eighty-nine percent of the variation in the dog count can be explained by the number of houses seen at the same location. The remaining eleven percent can be attributed to an unknown confounding variable or inherent variability."

Residuals vs fitted plot

Figure 14 shows that residuals have positive and negative values, averaging to zero. Their values (absolute values) are inferior for lower fitted values, which represent the pixels with lower dog count. For F4 dog model (figure 14, right size), the residuals take mainly negative values in a certain range (pixels with a number of dogs between 20 and 80 animals), having a maximum error of approximately 15 animals for pixels.

The outputs show residual variation on the island (figure 15). In general, the villages show positive and negative residual values. They also show that the residuals take the highest negative values in Porto Inglês centre.

Figure 14 - Residuals vs fitted plot for F2 and F4 dog model.

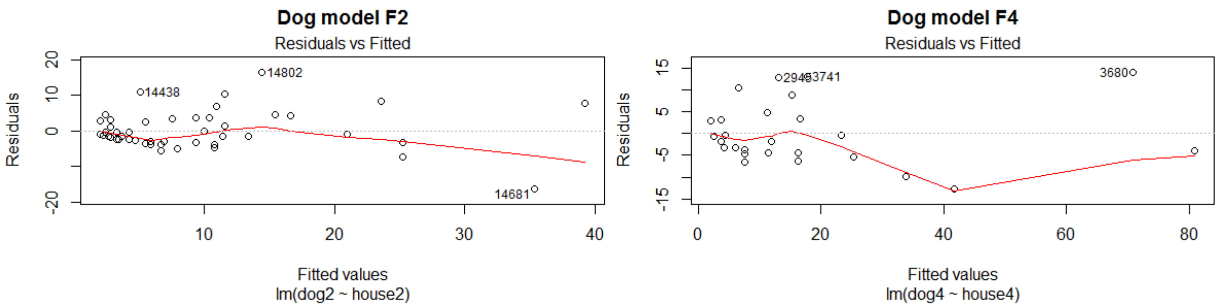
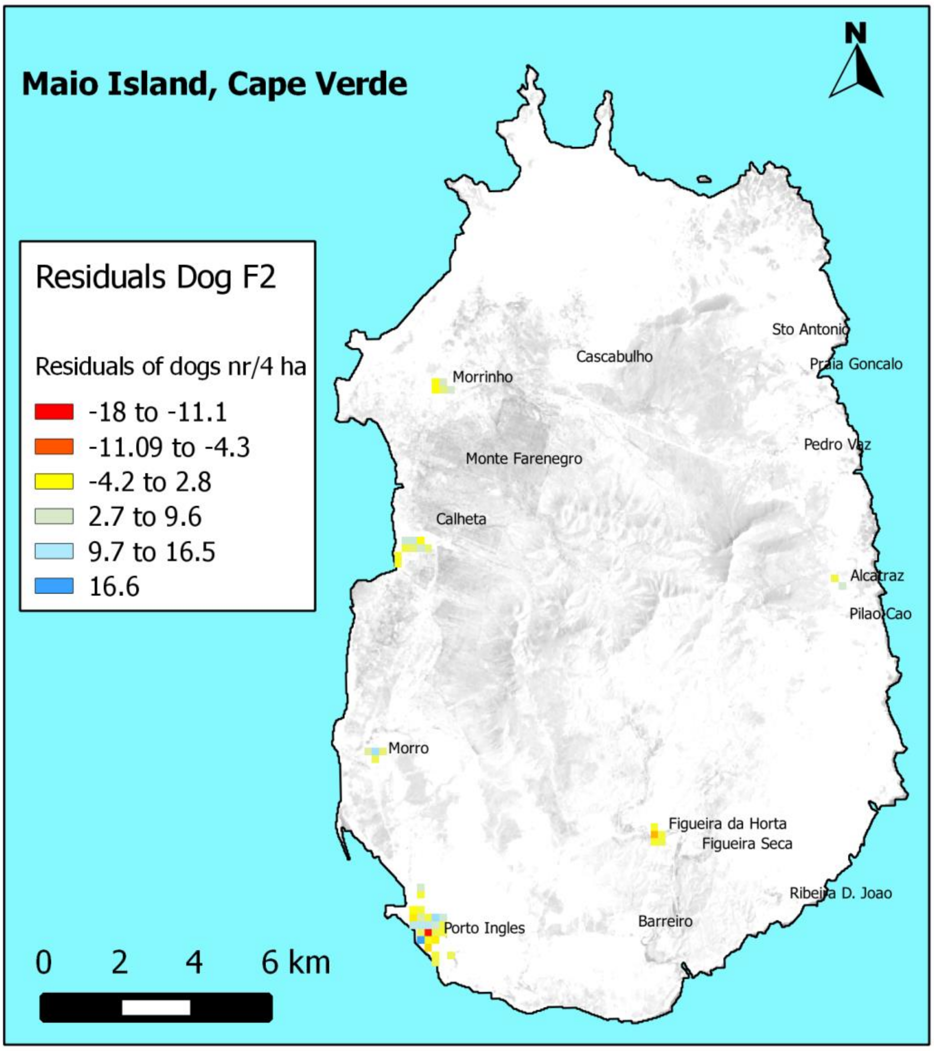


Figure 15 - F2 Dog model residuals distribution on Maio Island, Cape Verde.



Cross Validation

Figure 16 shows how the data was divided in 3 subsets. The similarity between the results in figures 16 and 13 (linear model) was expected since both plotted dog density against house density. The only different is that in these cases, each observation (point) has a symbol and a colour corresponding to the fold were it was insert to perform the cross validation.

Table 14 shows that the mean square prediction error (over-all MS) is higher for F4 dog model (59.8) when compared with F2 (39.1). This indicates that F2 dog model has a better performance in predict the results when applied to a different dataset.

Figure 16 - Observed values from F2 and F4 dog models divided into 3 subsets.

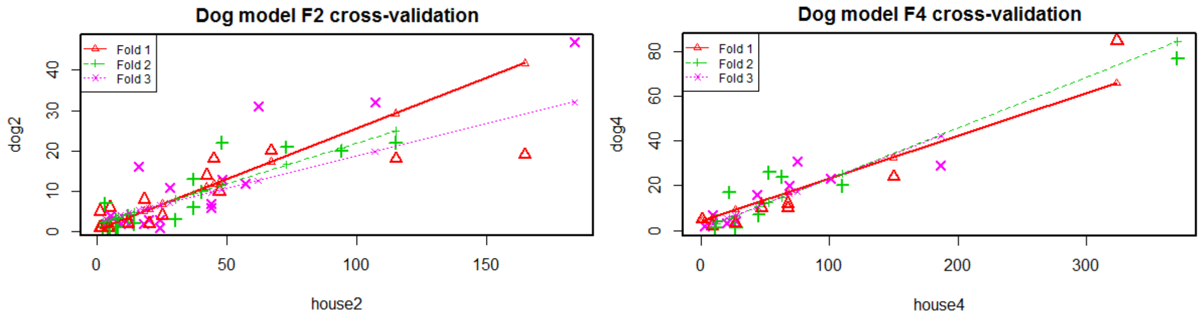


Table 14 - Cross validation results for F2 and F4 dog models.

Dog model	Fold (K-subset)	Number of observations	Sum Squared Error	Mean Squared Error	Over-all MS
F2	1	16	772	48.2	39.1
	2	17	236	13.9	
	3	17	945	55.6	
F4	1	8	581	72.6	59.8
	2	9	542	60.3	
	3	9	431	47.9	

Observation vs prediction

Comparing the results (table 15) both models underestimate the dog population. The error between both outcomes is higher for F2 (11.8%). Therefore, in this situation, the performance of F4 (7.4% of error) is better to estimate dog population size.

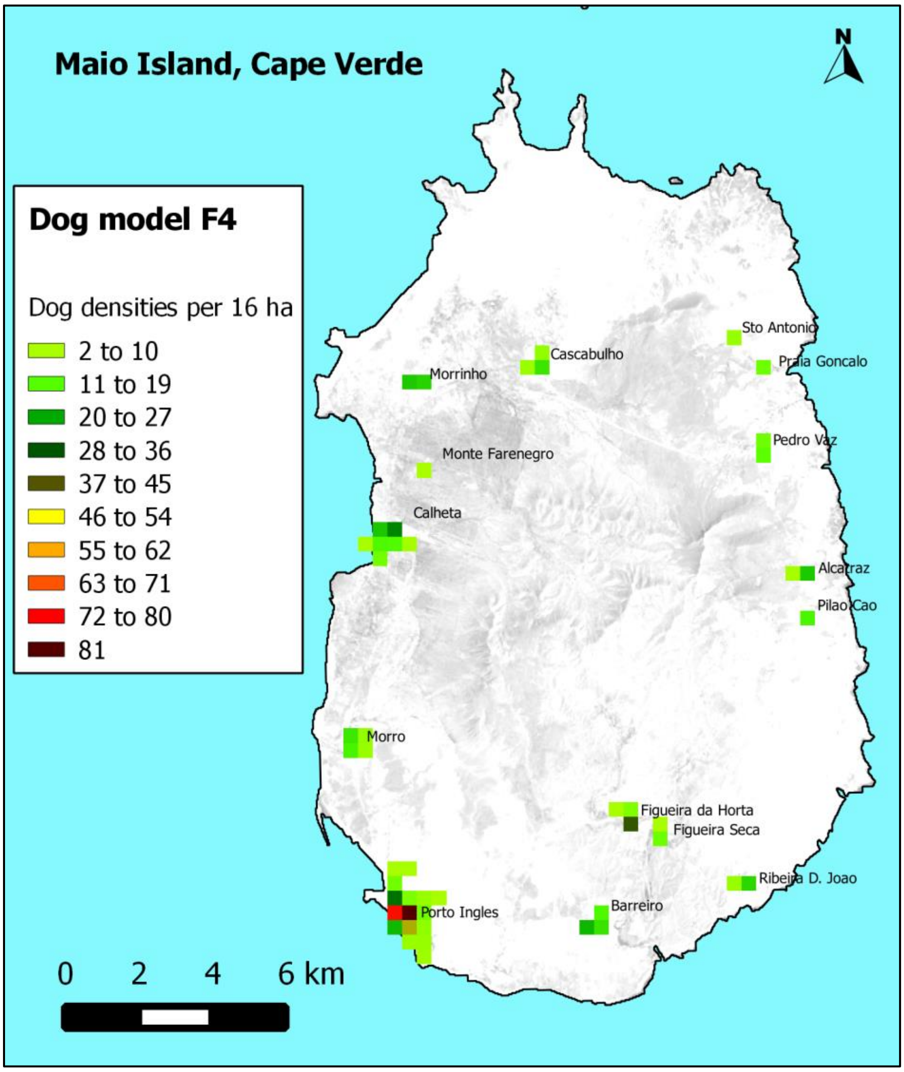
Table 15 - Model error rates for dog population in the six visited localities.

Model	Observed	Predicted	Error	Error %
F2	457	403	54	11.8
F4	457	423	34	7.4

4.2.4.1.2. Model selection and results

The F4 model was considered to be the best model due to its lower error rate when compared with F2 dog model. Thus, the predicted dog population size is 531 animals and its distribution is presented in figure 17.

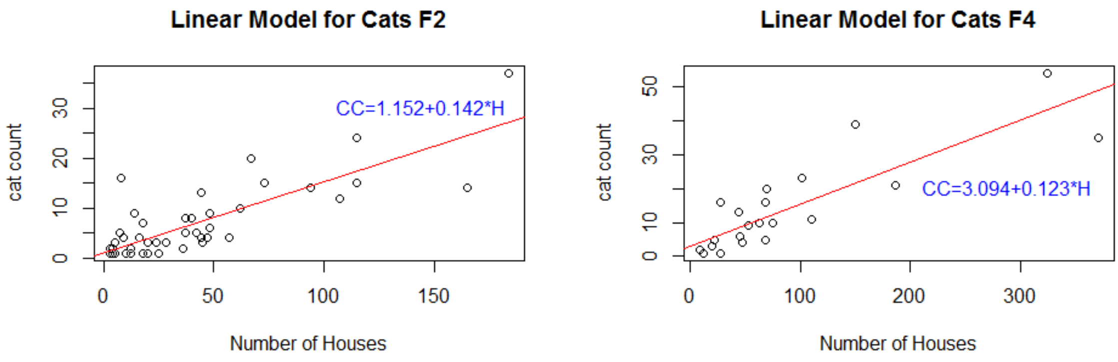
Figure 17 - Dog population size estimation and distribution on Maio Island, Cape Verde.



4.2.4.2. **Cat Model**

The linear models (figure 18) show that the slope value (0.1) is practically the same using pixels with 200 or 400 m size. This can be interpreted as: for each 10 houses added, the cat population increases with one individual on average.

Figure 18 - Linear regression models for estimating cat population.



4.2.4.2.1. Model evaluation

Coefficient of Determination

The results reveal that R^2 is higher for the model built based on 400 m resolution (F4) (R^2 = 0.73) than 200 m (F2) (R^2 = 0.65).

Residuals vs fitted plot

The residuals vs fitted plots were created for F2 and F4 models. According to figure 19, it is possible to state that the residuals average to zero. The plots show that in general, the residuals take inferior values (absolute values) for pixels with a lower number of cats.

Figure 20 shows that highest negative residuals occur in Porto Inglês, having 15 as the lowest and the highest absolute (modulus) value.

Figure 19 - Residuals vs fitted plot for F2 and F4 cat model.

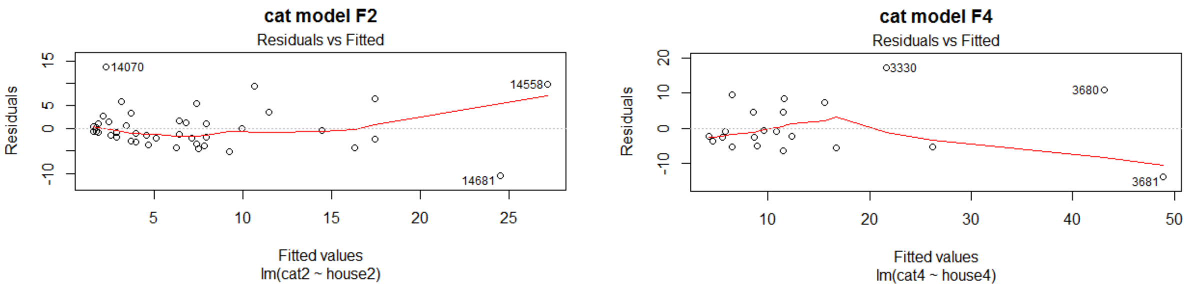
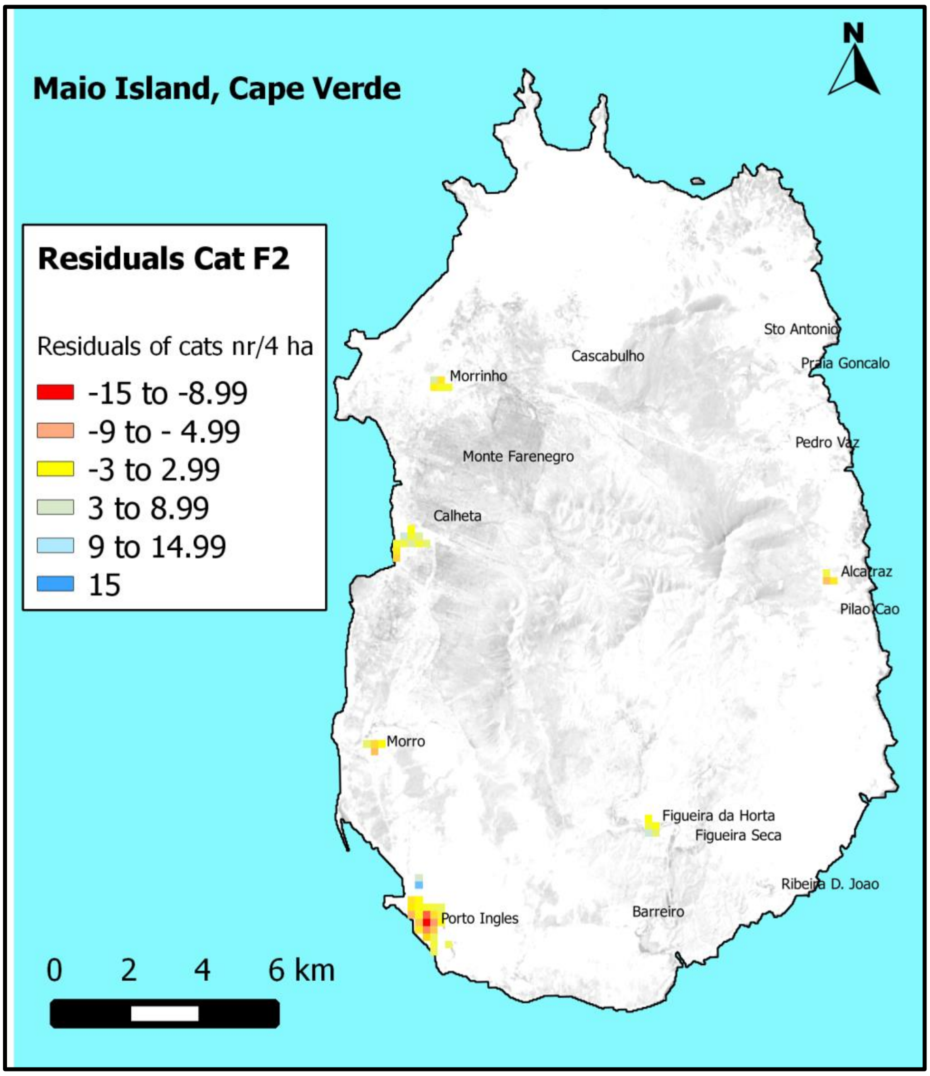


Figure 20 - F2 Cat model residuals distribution on Maio Island, Cape Verde.



Cross Validation

Figure 21 shows the data divided in 3 subsets and each symbol, with a matching colour, corresponds to a specific subset. As previously mentioned, the similarity between the results in figure 21 and figure 18 (model) was expected.

The result in table 16 shows that the overall MS is higher for F4 (104) when compared with F2 (19.9).

Figure 21 - Observed values from F2 and F4cat models divided into 3 subsets.

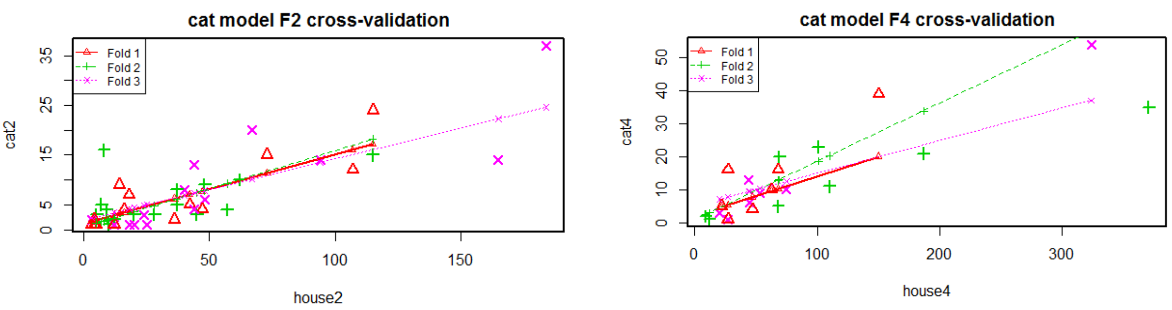


Table 16 - Cross-validation results for F2 and F4 cat models.

Cat model	Fold (K-subset)	Number of observations	Sum Squared Error	Mean Squared Error	Over-all MS
F2	1	14	163	11.6	19.9
	2	15	292	19.5	
	3	15	420	28	
F4	1	7	535	76.5	104
	2	8	1365	171	
	3	7	384	54.9	

Observation vs prediction

Comparing results in table 17, both models underestimate the cat population. However, F2 model presented a lower error rate (7.84%) when compared with the F4 model (19.61%).

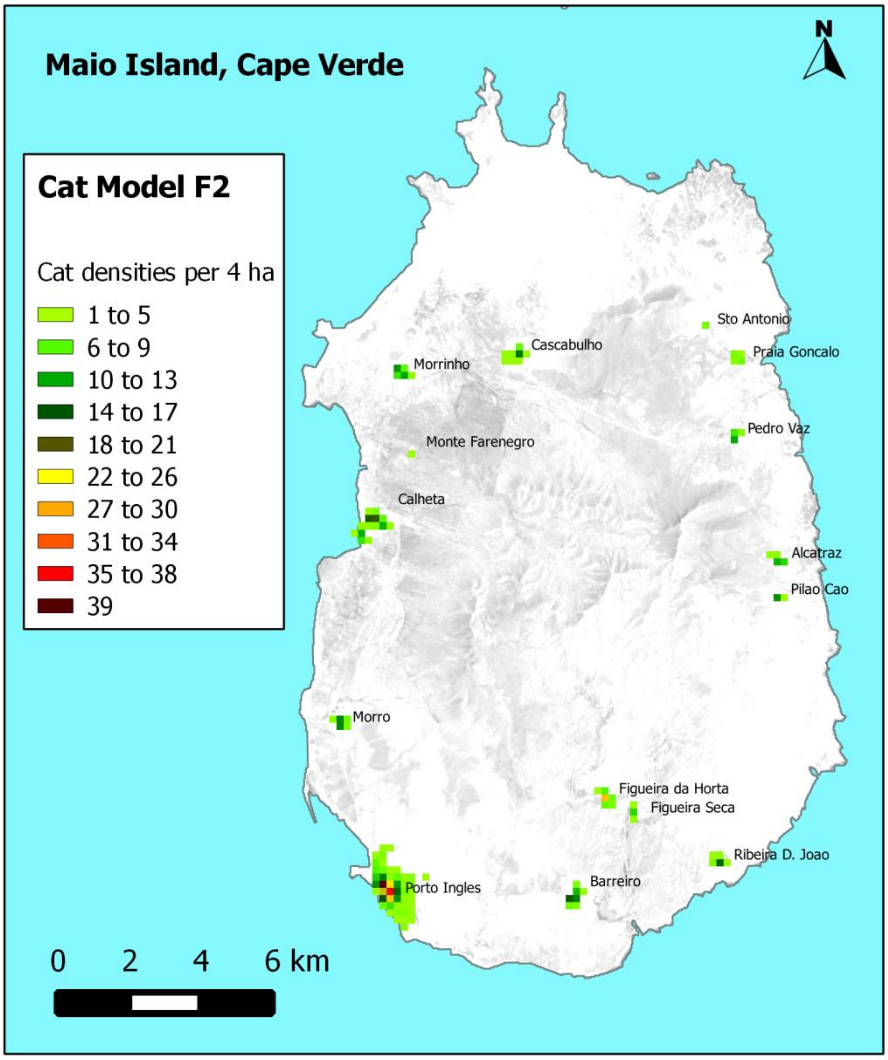
Table 17 - Model error rates for cat population in the six visited localities.

Model	Observed	Predicted	Error	Error %
F2	306	282	24	7.84
F4	306	246	60	19.61

4.2.4.2.2. Model selection and results

Based on model evaluation results, F2 model was designated as the best model for estimating cat population sizes on the island. Consequently, the predicted cat population size is 354 animals and its distribution is presented in figure 22.

Figure 22 - Cat population size estimation and distribution on Maio Island, Cape Verde.



4.3. Clinical observation of dogs and cats

4.3.1. General analysis

A total of 264 animals were examined during Companion animal health and welfare campaign promoted by the VSF-Portugal in Porto Inglês. Animals from other villages such as Alcatraz, Barreiro, Cascabulho, Figueira da Horta and Morro were also examined, corresponding respectively to 0.38%, 0.75%, 0.38%, 1.13% and 1.88% of the total of observed animals.
The dogs were the species more represented with 91.35% of the animal's total.

Table 18 - VSF-Portugal Companion animals health and welfare campaigns results.

		Dog	***Cat***
Total		243	21
Gender	Male	130	5
	Female	111	14
	Not define	2	2
Sterilized (%)	Male	31.54	20
	Female	36.04	14.29
Habitat (%)	Inside home	47.33	61.90
	Backyard	3.70	0
	Limited access to the street	30.04	28.57
	Free access	17.28	4.76
	On the street	1.65	4.76
Feeding (%)	Kitchen swill	90.12	95.24
	Commercial animals food	2.47	4.76
	Both	2.06	0
	Other	4.94	0

According to table 18, the dogs from both genders (31.54% for males and 36.04% for females) are sterilized in higher percentage when compared to cats (20 % and 14.29%).
About the habitat, it is possible to conclude that there is a significant number of animals living inside home or on the backyard (51.03 % of dogs, 61.90% of cats), followed by the number of

animals with limited access to the street (30.04% of dogs, 28.57% of cats). Other important fact was that 17.28 % of dogs and 4.75% of cats were considered as free-roaming.
Most of the animals (90% of dogs, 95% of cats) are fed with kitchen swill, and only 2.47 % of dogs and 4.76 % of cats are fed with commercial animal food. Some dog´s owners (4.94 %) mentioned that they cook rice, chicken and fish to feed their animals or provided milk.
The information gathered about animal's health reveals that only one dog was vaccinated against distemper and parvovirosis. The majority of animals (69.17%) were dewormed with ivermectin (active ingredient) at least once in their lives.
The owners referred that 23.31% of animal's had been sick before and the main symptoms were vomiting and diarrhea (4.89%), fainting (3.23%), bone fractures (3.23%), skin infections (3.32%), cough (2%), anorexia (1.61%), anemia (1.61%) and ophthalmic problems (1.61%).
There were no reports of the presence of cutaneous lesions in the animal's owners.

4.3.2. Clinical examination results

During the clinical exam, 4.51% of the animals were depressed and 12.78% were considered as thin and 12.88% as overweighed (body condition). The mucosa was pale in 4.51% of the animals and congested in 1.13%. Some animals presented alopecia (0.75%) and skin peeling (1.5%). External parasites were detected in 42.48% of the animals. Within these, ticks were detected in 71.68% of the animals, fleas in 4.42% and both in 7.52%. The lymph nodes were swollen (reactive) on 1.13% of the animals and 2.26% had diarrhea.
It was also possible to ascertain body injuries in 2.26% of the animals, dermatophytosis in 0.75%, broken legs in 0.38%, criptorchidia in 0.38% and also dehydration in 0.38%.

4.3.3. Comparison of results obtained during the clinical exam and on the survey of dog and cat population

Comparing proportions found in VSF data with those found in the survey, there were significant differences for proportion of males for both species ($z=2.0623$, $p=0.039$ for dogs and $z=2.306$, $p=0.021$ for cats) where VSF data had less males than the survey. Results also reveal that the proportion between both studies are different for sterilized female dogs ($z=4.492$, $p<0.00006$), with VSF data with a larger proportion, and sterilized male dogs ($z=2.965$, $p= 0.0031$), with VSF data also showing a larger proportion. Results obtained for the proportion of species, degree of dependence and skin changes showed no significant differences in both sources of data.

Furthermore, lager proportions were found in VSF database for ‘restricted access to the street’ both for dogs ($z=2.726$, $p=0.006$) and cats ($z=2.804$, $p=0.0051$).

5. Discussion

5.1. Importance of the study and expectations

There is a lack of studies focused on estimation and characterization of dog and cat population size in African countries. Despise of the fact that cats may be responsible for transmitting zoonoses, these studies tend to be focused mainly on dog populations due to the role of this specie in rabies transmission. Moreover, international and non-governmental organizations have been developing several projects in order to promote public health in Africa, meanly focuses on rabies control underestimating other possible zoonotic diseases.

Despise of the fact that Cape Verde has no reports of major zoonotic diseases (World Organisation for Animal Health, 2013), its geographical location facilitates the spread of diseases from other African countries as a result of global transport networks, which includes economic activity, tourism and human migration. This fact highlights the importance of surveillance systems as an early warning system, for planning strategies and monitoring the control actions and even creates emergencies plans for certain diseases.

Current clinical techniques for monitoring animal health in this country provide sporadic information and require too much resource investment in terms of time and veterinary expertise. There is no surveillance system dedicated to companion animals or official vaccination, deworming and sterilisation programs. It is recognised that stray animals and their potential risks for public health are important and recent investments have been made by Municipalities to address the problem. Syndromic surveillance systems can be used to overcome the lack of infrastructures and financial resources since it is based on observation of signs easy to identify and its reporting, not requiring laboratory diagnostic. These systems can be used for early detection of outbreaks, giving enough time to apply contingency plans for those diseases, and thereby avoiding high economic losses resulting from animal’s death, expensive measures, trade restrictions and people medical care (zoonoses).

The results of this project are an added value since it provides the baseline information to plan future companion animal health and welfare campaigns and to set up a syndromic surveillance system on this island. This system can also be used not only for surveillance of companion animals endemic and exotic diseases, such as mange or rabies, but also in other species and diseases important for the country such as African Swine Fever (swine) and Brucellosis (small ruminants).

Furthermore, the developed models for estimating dog and cat populations could be used in other island of Cape Verde, helping to plan surveillance programs, vaccination, deworming and sterilisation programs at national level.

5.2. Data collection procedures

Data collection is one of the most important and expensive steps in research. Methodologies should be chosen so that financial and human resources are used as effectively as possible, which may imply a multi-method approach.

The questionnaires were applied face-to-face, helping to develop an empathy with the local residents which is very important for their participation in the study. It also allowed high degree of control over the data collection process and environment. Other advantage of this methodology is that the purpose of the study could be fully explained, which is very important to ensure the participant compliance and eliminate the problems of missing data.

This methodology offers many advantages over mail and telephone surveys in terms of the complexity, financial resources and data quality. However, these advantages come with a significantly increased logistics cost as it is necessary to hire manpower and is geographically limited to areas close to interviewer. In other social-economic contexts, telephone and mail surveys can be used to collect data. Nonetheless, the advantages and disadvantages of each methodology need to be weighted in each situation.

The approach of applying the questionnaires to every single house on Maio Island would also not be suitable in larger cities without financial and human resources. Thus, a good option would be to use the same methodology as Alves et al. (2005) used in São Paulo, Brazil to estimate dog and cat populations. This author surveyed 41 municipalities and defined census tracts based in probabilistic stratified cluster sampling in two different stages: a visit to homes to apply questionnaires and hand over dog and cat collars, and counting animals on the streets. Another possible approach could be dividing the city in a set of subregions, which cover the entire region of interest and are non-overlapping. This was the approach chosen for Porto Inglês, the only city on the island.

The literature research carried out could not find any other study using GIS software to estimate dog and cat populations in Africa. GIS techniques were crucial to find a relationship between animal and human counts, which other authors such as Butler & Bingham (2000) did not find. Rinzin (2007) also used GIS techniques and found a positive relationship between human population density and dog and cat density in a region of New Zealand. This clearly shows the potential of applying these techniques to estimate and characterise animal populations in Africa.

Currently there are many open-source information and software that can be applied in animal population studies.

For this study, Google™ Earth imagery was used to estimate the number of households across the island. Despite the advantage of being an open source program, this approach has several limitations:

- does not allow to distinguish households from commercial or governmental buildings;
- assumes all houses are occupied;
- it is no possible to differentiate buildings with several floors;
- recent images could not be available for certain areas;
- resolution may be too low to distinguish each building.

This approach would not be suitable for larger cities since it would take a long time to "mark" each building. To overcome this issue, other sorts of remotely-sensed data can be used to estimate human population density. Night-time imagery, enhanced vegetation index (EVI), digital elevation model (DEM) and spectral radiance have been recently combined and modelled to produce high-resolution population distribution models (Li & Weng, 2005; Yang, Yue & Gao, 2013). Other possible approach is to use data available at the Gridded Population of the World (GPW) website developed by NASA Socioeconomic Data and Applications Center (SEDAC) to know the population size in a certain region.

It is also possible to survey other relevant data such as the number of inhabitants in each household, percentage of main religious types, housing types or services; as it can be used to improve the accuracy of the estimate and map the distribution of roaming animal numbers according to the social-economic context of the study area.

5.3. Survey of the dog and cat population

Despise of the fact that several sterilization and deworming campaigns have been performed over the last years on the island, these activities were centralized in Porto Inglês. This justified the fact that sterilized animals were only identified in Porto Inglês and Morro, the nearest village. In the future, these campaigns should be extended to other villages to contribute and promote animal and public health in other places on the island.

In terms of restriction and dependence, it was possible to verify that a high percentage of animals lived indoors with limited access to the street, highlighting the importance, affection and esteem of these animals for this community.

It is possible to state that stray and neighbourhood animals only existed in Porto Inglês. The fact of existing food wasted outside of the rubbish cans on the street and people feeding their animals outside home, contributes to the survival of feral dogs. However it is possible that the animals mentioned as neighbourhood or feral are owned by someone whom lives in other area of the village and found an “addition” spot to be feed. These numbers also praise the work done by VSF-Portugal on the last years in this island, contributing to the control of free-roaming animals’ populations.

Results showed that animals tend to be younger in rural areas (smaller villages) Porto Inglês was the only village where older cats were identified. This fact can be explained by the Companion animals health and welfare campaigns performed in this village but also by the highest number of people employed. Thus, people have higher economic resources, providing a better quality of life to their animals and increasing their life expectancy.

The ratio animal:human obtained for visited localities on Maio Island were similar to the ratios obtained in Zimbabwe (Brooks, 1990), Tanzania (Knobel et al., 2008) and Chade (Mindeken et a.l, 2005) for urban areas. However, when comparing the results obtained by Knobel et al. (2005) for urban areas in South Africa, the ratio was lower on Maio Island. This difference could possible due to the minor villages’ dimensions and the lack of social-economic development in contrast with other big cities in Southern Africa.

Pearson correlation coefficients results demonstrated that is a very strong relationship between demographic variables and animal population. These results were expected since the majority of African families have on their structure individuals who belong to all age groups, including children, adolescents, adults and seniors.

5.4. Modelling process

The first step on modelling process is to build the model.

As previously mentioned, the number of houses was defined as the only predictive variable, resulting in simple linear regression models. When simple regression models are used to develop prediction models, sample size must be large enough to find a relationship between variables and ensure stable coefficients. In this survey, only six localities were visited. If the “raw” data was used, i.e., the total number of dogs, cats and houses in each locality, the model would be build based only in 6 observations. To overcome this situation, the sample size was increased using spatial distribution of data and processing methodologies.

As a second step, several statistical methodologies were used to validate and help decide upon the final regression model, and to determine how well the model will perform in practice.

According to residuals distribution maps, there were regions where the residuals show negative values. The reason of these values is that the model predicts a higher number of animals for those areas based on the number of houses. In other words, according to the model, the observations were underestimated for those regions.

As mentioned before, Porto Inglês is the main city on the island with the highest population and house density where several commercial and governmental buildings exist.
According to the model, the observed animal's population was underestimated (warm colours) in some areas possibly due to the fact that the images used to calculate the house density take into account all buildings, not allowing to distinguish between commercial, governmental and housing buildings. These images also can result in the overestimation of the number of houses, especially when its density is very high. If the images do not have a good contrast, it will not allow to clearly distinguish the house limits, which can result in a double-count of the same building.
For other areas, where the residuals had positive values (cold colours), the number of animals was overestimated. One explanation for these values could be that Google™ Earth images did not allow to distinguish buildings with several flats and floors.
These examples illustrate the disadvantages previously mentioned of using Google™ Earth images to calculate house density.
In general, residuals vs fitted values plots indicate that the performance of the models for both species is better for lower fitted values. These results were expected since the training data mainly consisted of villages where animal density is lower. Therefore, the models were build based on these data and have a better performance in this situations when compared with places with a high animal densities, e.g. in Porto Inglês.
Due to the small number of sampled size, the cross validation was done to assess the predictive performance of the models. The advantage of this methodology was to use the entire training set for testing, creating several possible test sets for a fixed training data set.
According to the results obtained, the mean square prediction error was higher for F4 models for both species. This could be explained by the sample size be lower for F4 models (26 and 22 observations for dogs and cats respectively) when compared with F2 models (50 and 44 observations for dogs and cats respectively), resulting in models with a poor predictive performance accuracy (over-fitted) when applied to new data.
The third and last step of the modeling process is model selection. Every introductory book on regression analysis contains chapters on ways of choosing among competing models. Many authors have examined this question and many tools for selecting the "best model" have been suggested in the literature. With such prosperity of methods, it can be difficult to decide what would be the appropriate way to proceed.
Since the objective was to select the "best" predictive model, it was assumed that the selection would be based on the evaluation of the error rate between the observed and predictive results obtained for the six communities. For this reason, F2 model and F4 models were selected to

estimate cat and dog populations respectively. It is also important to mention that the results from both models were underestimated when compared with the observed animals. One possible reason for this could be the fact that the number of houses included on the model was calculated based on Google Earth imagery. As previously mentioned, the use of these images can result in a lack of accuracy on the prediction of the number of households.

These models can be applied in other islands of Cape Verde since the social-economic context is similar. However, further investigation is advised to improve the model accuracy by including other factors, which could influence animal detention such as the number of people living in the house or their financial situation. In this project, these sorts of data were not collected on the survey and there are no sources of this information available for the country and hence, their use would not provide advantages to the project.

The results also demonstrate that data processing parameters (i.e. aggregation factors) had a direct effect on model performance.

5.5. Clinical observation of dogs and cats

As previously discussed, sterilization and deworming campaigns only took place in Porto Inglês, resulting in a high percentage of non-sterilized animals than in other villages. Other fact that contributes to these percentages is, although the veterinaries' efforts to inform the population about the benefits of sterilization, some animal's owners were not interested in performing such procedures.

As literature review showed, one of the major concerns with stray dogs in this country is the potential transmission of mange (zoonotic disease) and physical injuries resulted from dog bites. A special attention is given to mange (scabie), being responsible for public health problems in many developing countries, related primarily to poverty and overcrowding. Despise of the fact that animal's owners did not reported any skin lesions indicative of this possible zoonotic disease, it is important to perform clinical examinations to animals. Frequently the clinical symptoms, such as itchy lesions, are only detected after 4 to 6 weeks of the primary infestation and transmission to others often occurs prior to therapy (Walton & Currie, 2007).

Haemoparasites should also be considered as important concern due to the large number of animals which showed presence of ticks and fleas, or both. The presence of animals with adenomegaly, depression, weight loss, poor body condition and mucopurulent ocular discharge (which could be described as ophthalmic problems by the owners) could sustain the presence of diseases caused by parasites. Further studies are recommended to confirm this hypothesis based on laboratory techniques. It is important to mention that these diseases can also be transmitted to humans, such as the Rickettsioses and Ehrlichiosis.

5.6. Comparison of results obtained during the clinical exam and on the survey of dog and cat population

According to results, the proportion of males from both species is different in both surveys. This was expected since animal's owners are more conscience that female's sterilization and its health have a very important impact on controlling animal population, resulting in a higher number of females observed on the VSF-Portugal campaign when compared to the survey applied in several villages across the island.

The proportion for sterilized animals for both genders of dog population are also different for both studies, which is expected as one of the most important reasons for people seeking animal companion health and welfare campaigns it the sterilization of their animals.

Relatively to the number of animals with limit access to the street, results revealed that proportions are different between both surveys. This can results from the fact that animals observed during the VSF campaign were mainly owned by people resident in Porto Inglês, the only city on the island, where there is a higher concern in allowing the presence of animals on the street, due to potential physical dangerous on animals caused by car traffic. This situation does not occur in villages, which corresponds to 5 of 6 visited localities, where animals are allowed to have limit access to the streets.

Results show that care must be taken to the deviations from population representativeness when incorporating clinical data into surveillance systems.

6. Conclusions

This study allowed a direct contact with a new culture where people establish good relationships and mutual support. This was very beneficial for the survey, allowing to obtain a high responses rate for the questionnaires and ensure data quality. It was also possible to verify the concern of people to take their animals to the VSF- Portugal campaign. Thus, it can be assumed that the small companion animals have an important social status on this island.

Despite the lack of funds to finance the campaigns in Maio Island, VSF – Portugal have been doing efforts to promote public and animal health. They have an important role in animal's population control, raising public awareness and helping to obtain resources to support programmes for responsible ownership, including sterilization and deworming procedures.

One of the most important conclusions was the fact that stray animals were not a concern on Maio Island in contrast with other islands in Cape Verde; despite of the fact that animals have free access to the street, all animals were owned. Porto Inglês was the only city where feral dogs and cats were identified, praising the work done by VSF-Portugal over the last years.

Remotely sensed data and GIS tools were crucial to accomplish the objective of this study. This methodology revealed to be an added value in terms of assessing population sizes when financial resources are restricted. A similar approach could be used to estimate dog and cat population in areas with a similar socio-economic context, especially in developing countries. In different settings, other types of remotely sensed data and approaches could be used without requiring large financial investments.

These tools allowed to find a relationship between human, dog and cat populations which, to my knowledge, no other author had found before in an African country. The predictive models were built and chosen based on the precision and spatial accuracy at village level. The population estimate was 531 dogs and 354 cats and distribution maps for both species were created for the entire island. The results also demonstrated that spatial aggregation has an impact on predictive models.

In summary, this study highlights the potential of geographic information systems in population size estimates and praises the efforts done by non-governmental organizations on this island in order to promote public health.

7. Bibliography

A Semana (2012). *São Filipe: Cães vadios têm os dias contados e serão abatidos*. Accessed September 29th, 2012, from: http://www.asemana.publ.cv/spip.php?article78962

Aanensen, D.M., Huntley, D.M., Feil, E.J., al-Own, F. & Spratt, B.G. (2009). EpiCollect: Linking Smartphones to Web Applications for Epidemiology, Ecology and Community Data Collection. *PLoS ONE, 4*(9), e6968.

Abbas, M. (2011). *Statistical Estimation of Wild Animal Population in Finland: A Multiple Target Tracking Approach*. Master Thesis. Espoo: Aalto University. Accessed February 5th, 2013, from Aalto University Digital Library: https://aaltodoc.aalto.fi/handle/123456789/3794

Acha, P.N. & Szyfres, B. (2003). *Zoonoses and Communicable Diseases common to Man and Animals*. (3rd ed.). Vol.1 & 2. Washington, DC: Pan American Health Organization, Scientific and Tech. Publications.

Alves, M.C., Matos, M.R. de, Reichmann, M. de L. & Dominguez, M.H. (2005). Estimation of the dog and cat population in the State of São Paulo. *Revista de Saúde Pública*, 39(6), 891-897.

American Veterinary Medical Association (2008). *One health initiative task force. "One Health: A New Professional Imperative"*. Accessed October 3rd, 2012, from American Veterinary Medical Association website: http://www.avma.org/onehealth/onehealth_final.pdf

Asher, L., Buckland, E.L., Phylactopoulos, C.I., Whiting, M.C., Abeyesinghe, S.M. & Wathes, C.M. (2011). Estimation of the number and demographics of companion dogs in the UK. *BMC Veterinary Research*, 7 (1), 74.

Associação - SOS Cães e Gatos de Cabo Verde Santa Maria, Ilha do Sal, Cabo Verde (2012, March). Campanha de castração/esterilização de cães e gatos - Janeiro 2012 - report introdução. Accessed 29th September, 2012, from: http://www.cvcatsanddogs.com/projects-1

Beran, G.W. & Frith, M. (1988). Domestic animal rabies control: an overview. *Rev Infect Dis*, 10 Suppl 4:S, 672-677.

Björnstig, U., Eriksson, A. & Örnehult, L. (1991). Injuries caused by animals. *Injury*, 22 (4), 295-298.

Bokkers, E. (2006). Effects of interactions between humans and domesticated animals. *Farming for health*, 31 - 41.

Bratton, R.L., Whiteside, J.W., Hovan, M.J., Engle, R.L. & Edwards, F.D. (2008). Diagnosis and treatment of Lyme disease. *Mayo Clinic proceedings*. Mayo Clinic, 83(5), 566-571.

Brooks, R. (1990). Survey of the dog population of Zimbabwe and its level of rabies vaccination. *Veterinary Record*, 127, 592-596.

Butler, J. R. A. & Bingham, J. (2000). Demography and dog-human relationships of the dog population in Zimbabwean communal lands. *Veterinary Record,* 147 (16), 442-446.

Carmelo, C.O., Calzolari, M., Casalone, C., De Meneghi, D., Dottori, M., Estrada-Peña, A., Fabbi, M., Ferreri, L., Ferroglio, E., Luini, M., Mannelli, A., Martello, E., Pautasso, A., Prati, P., Tomassone, L., Solano, M. N. & Vesco, U. (2012). External scientific report: Inventory of available data and data sources and proposal for data collection on vector-borne zoonoses in animals. Available from the European Food Safety Authority website: http://www.efsa.europa.eu/en/supporting/doc/234e.pdf

Castanheira, P.J. de C.M. (2012). *Rastreio virológico de cães errantes da cidade de Vila do Maio, Cabo Verde.* Dissertação de Mestrado em Medicina Veterinária. Lisboa: Faculdade de Medicina Veterinária – Universidade Técnica de Lisboa.

Chretien, J.P., Burkom, H.S., Sedyaningsih, E.R., Larasati, R.P., Lescano, A.G., Mundaca, C., Blazes, D.L., Munayco, C.V., Coberly, J.S., Ashar, R.J. & Lewis, S.H. (2008). Syndromic Surveillance: Adapting Innovations to Developing Settings. *Plos Medicine*. Volume 5, Issue 3, e72, 367.

Costa, F.L., Alves-da-Silva, A. & Ventura, J. E. (2011). Contributos de geografia física para a gestão integrada do litoral da Ilha da Boavista. Accessed April 23rd, 2013, from: http://www.igeo.pt/eventos/comunicacoes/Cabo_Verde/VICong_PGZCPEP_CGF_AntonioSilva.pdf

Day, M.J. (2011). One health: the importance of companion animal vector-borne diseases. *Parasites & Vectors*, 4(1), 49.

De Balogh, K.K., Wandeler, A.I. & Meslin, F.X. (1993). A dog ecology study in an urban and a semi-rural area of Zambia. *Onderstepoort Journal of Veterinary Research*, 60, 437 – 443.

Dórea, F.C., Revie, C.W., McEwen, B.J., McNab, W.B., Kelton, D. & Sanchez, J. (2012). Retrospective time series analysis of veterinary laboratory data: Preparing a historical baseline for cluster detection in syndromic surveillance. *Preventive Veterinary Medicine*, 109, 219 – 227.

Ernest, S. (2013). *INSIGHT: Monitoring human and livestock health the Smart Way*. Accessed April 25th 2013 from:http://www.androtab.net/android-mobiles/insight-monitoring-human-and-livestock-health-the-smart-way/

Evans, R. (1992). *Life cycle and animal infection.* In: Ho-Yen, D., Joss, A.W.L. (Eds.), Human Toxoplasmosis. Oxford New York Tokyo: Oxford Medical Publications, 26-55.

Fei, S.Y., Chiang, J.T., Fei, C.Y., Chou, C.H. & Tung, M.C. (2012). Estimating stray dog populations with the regression method versus Beck's method: a comparison. *Environmental and Ecological Statistics Journal*,Springer Editions, 19, 485-498.

Fekadu, M. (1993). Canine rabies. *Onderstepoort Journal of Veterinary Research,* 60, 421-427.

Ferreira, J.P., Anderson, K.L., Correa, M.T., Lyman, R., Ruffin, F., Reller, L.B. & Fowler, V.G. (2011). Transmission of MRSA between Companion Animals and Infected Human Patients Presenting to Outpatient Medical Care Facilities. *PLoS ONE*, 6(11), e26978.

Fishbein, D.B., Frontini, M.G., Dobbins, J.G., Flores Collins, E., Quiroz Huerta, G., Gamez Rodriguez, J.J., Woo-Ming, B., Garza Ramos, J., Belotto, A.J. & Balderas Torres, J.M. (1992). Prevention of canine rabies in rural Mexico: an epidemiologic study of vaccination campaigns. *The American Journal of Tropical Medicine and Hygiene*, 47, 317-327.

Flores-Ibarra, M. & Estrella-Valenzuela, G. (2004). Canine ecology and socioeconomic factors associated with dogs unvaccinated against rabies in a Mexican city across the US-Mexico border. *Preventive Veterinary Medicine*, 62, 79-87.

Font, E. (1987), Spacing and social organization: Urban Stray dogs revisited. *Applied Animal Behaviour Science*, 17, 319-328.

Fretwell, P.T., LaRue, M.A., Morin, P., Kooyman, G.L., Wienecke, B., Ratcliffe, N. & Trathan, P. N. (2012). An Emperor Penguin Population Estimate: The First Global, Synoptic Survey of a Species from Space. *PLoS ONE*, 7(4), e33751.

Gagne, S.S. (2001). Toxoplasmosis. *Prim Care Update Ob/Gyns*. 8, pp.122-6.

Geffray, L. (1999). Infections associated with pets. *La Revue de Médecine Interne*, 20 (10), 888-901.

Götsch, S., Leschnik, M., Duscher, G., Burgstaller, J.P., Wille-Piazzai, W. & Joachim, A. (2009). Ticks and haemoparasites of dogs from Praia, Cape Verde. *Veterinary parasitology*, 166 (1-2), 171–174.

Guasticchi, G., Rossi, P.G., Lori, G., Genio, S., Gabriele, S. & Borgia, P. (2009). The emergency visit-based syndromic surveillance of the Lazio region. Results of the pilot phase, 4, 5.

Halliday, J., Daborn, C., Auty, H., Mtema, Z., Lembo, T., Bronsvoort, B.M. & Cleaveland, S. (2012). Bringing together emerging and endemic zoonoses surveillance: shared challenges and a common solution. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1604), 2872-2880.

Hines, R. (2012). *We Catch From Our Pets, Zoonotic Illness Of Dogs Cats And Other Pets.* Accessed January 25th, 2013, from: http://www.2ndchance.info/zoonoses.htm.

Hunter, L., Corbett, W. & Grindem, C. (1989). Zoonoses updated: Anthrax. *Journal of the American Veterinary Medical Association*, 8, 1028-1031.

Hutwagner, L., Thompson, W., Seeman, G.M. & Treadwell, T. (2003). The bioterrorism preparedness and response Early Aberration Reporting System (EARS). *Journal of Urban Health*, 80:i89-96.

Instituto Nacional de Estatística (INE) (2012). Census 2010. Accessed February 27th, 2013, from: http://www.ine.cv/censo/censo2010.aspx

Kaare, M., Lembo, T., Hampson, K., Ernest, E., Estes, A., Mentzel, C. & Cleaveland, S. (2009). Rabies control in rural Africa: evaluating strategies for effective domestic dog vaccination. *Vaccine*, 27, 152-160.

Kitala, P.M., McDermott, J.J., Kyule, M.N., Gathuma, J.M. & Perry, B.D. (2001). Dog ecology and demographic information to support planning of rabies control in Machakos District, Kenya. *Acta Tropica*, 78, 217-230.

Knobel, D.L., Cleaveland, S., Coleman, P.G., Fèvre, E.M., Meltzer, M.I., Miranda, M.E., Shaw, A., Zinsstag, J. & Meslin, F.X. (2005). Re-evaluating the burden of rabies in Africa and Asia. *Bulletin of the World Health Organanization*, 83, 360- 368.

Knobel, D.L., Laurenson, M.K., Kazwala, R.R., Boden, L.A. & Cleaveland, S. (2008). A cross-sectional study of factors associated with dog ownership in Tanzania. *BMC Veterinary Research*, 4, 5.

Kongkaew, W., Coleman, P., Pfeiffer, D.U., Antarasena, C. & Thiptara, A. (2004). Vaccination coverage and epidemiological parameters of the owned-dog population in Thungsong District, Thailand. *Preventive Veterinary Medicine*, 65, 105-115.

Li, G. & Weng, Q. (2005). Using Landsat ETM+ Imagery to measure population density in Indianapolis, Indiana, USA. Photogrammetric Engineering & Remote Sensing, Vol. 71, No. 8, August 2005, 947-958.

Lima, A.S. & Garcia, E.M.O. (2011). *Gestão de águas subterrâneas em ambientes insulares: caso de estudo da ilha do Maio (Cabo Verde).* VI Congresso Planeamento e Gestão das Zonas Costeiras dos Países de Expressão Portuguesa. Ilha da Boa Vista. Cabo Verde. Accessed December 23rd, 2012, from: http://repositorium.sdum.uminho.pt/

Liu, J.G. & Mason, P.J. (2009). *Essential Image Processing for GIS and Remote Sensing*. Wiley-Blackwell, p. 4. ISBN 978-0-470-51032-2.

Louzã, A.C. (2007). The Sharing of Urban Areas by Man and Animals. In M. S. Pereira (Ed), A Portrait of State-of-the-Art Research at the Technical University of Lisbon, pp 479-488, Springer Netherlands.

Mandl, K.D., Overhage, J.M., Wagner, M.M., Lober, W.B., Sebastiani, P., Mostashari, F., Pavlin, J.A., Gesteland, P.H., Treadwell, T., Koski, E., Hutwagner, L., Buckeridge DL, Aller, R.D. & Grannis, S. (2004). Implementing syndromic surveillance: a practical guide informed by the early experience. *Journal of the American Medical Informatics Association*, 11 (2), 141-150.

May, L., Chretien, J.P. & Pavlin, J.A. (2009). Beyond traditional surveillance: applying syndromic surveillance to developing settings – opportunities and challenges. *BMC Public Health*, 9 (1), 242.

Meslin, F.X. (1992). Surveillance and control of emerging zoonoses. World health statistics quarterly. *Rapport trimestriel de statistiques sanitaires mondiales*, 45 (2-3), 200.

Miller, B., Kassenborg, H., Dunsmuir, W., Griffith, J., Hadidi, M., Nordin, J.D. & Danila, R. (2004). Syndromic surveillance for influenza like illness in ambulatory care network. *Emerging Infectious Diseases* 004,10:1806-1811.

Mindekem, R., Kayali, U., Yemadji, N., Ndoutamia, A.G. & Zinsstag, J. (2005). Impact of canine demography on rabies transmission in N'djamena, Chad. *Med Trop* (Mars) 65, 53-58.

Ndegwa, C.M. & Murayama, Y. (2009). Analysis of Land Use/Cover Changes and Animal Population Dynamics in a Wildlife Sanctuary in East Africa. *Remote Sensing*, 1(4), 952-970.

Noguera, E.A.S. & Barbosa, F. (2007). La situation zoo-sanitaire au Cap Vert. *Bulletin de l' Óffice International des Epizooties*, Vol. 2007, 2, 33-35.

Nsubuga, P., White, M.E., Thacker, S.B., Anderson, M.A., Blount, S. B., Broome, C.V., Tom M. Chiller, T.M., Espitia, V., Imtiaz, R., Sosin, D., Stroup, D.F., Tauxe, R.V., Vijayaraghavan, M. & Trostle, M. (2006). Public Health Surveillance: A Tool for Targeting and Monitoring Interventions. In *Disease Control Priorities in Developing Countries* (2nd ed). (pp 997 - 1015). Washington (DC): World Bank.

Oboegbulem, S.I. & Nwakonobi, I.E. (1989). Population density and ecology of dogs in Nigera: A pilot study. *Revue Scientifique et Technique de l'Óffice International des Epizooties*, 8, 733-745.

Pan American Health Organization (PAHO) & Acha, P.N. (2003). *Zoonoses and Communicable Diseases Common to Man and Animal, Volume III: parasitoses.* (3rd Ed). (pp vii). Washington: PAHO, WORLD HEALTH ORGANIZATION. ISBN 92 75 31992 8 (Vol. 3).

Pereira, C., Almeida, C., Malta, M., Vilaça, R. & Payo-Puente, P. (2013). First report of Dirofilaria immitis in the Republic of Cape Verde. *Veterinary Parasitology*, *192*(1–3), 290–291.

Perry, B.D. (1993). Dog ecology in eastern and southern Africa: implications for rabies control. *The Onderstepoort journal of veterinary research*, 60 (4), 429-436.

Perry, B., Kyendo, T., Mbugua, A., Price, J. & Varma, S. (1995). Increasing rabies vaccination coverage in urban dog populations of high human population density suburbs: A case study in Nairobi., Kenya. *Preventive Veterinary Medicine*, 22, 137-142.

Petrie, A. & Watson, P. (2001). Statistics for Veterinary and Animal Science. (1st Ed.) UK: Blackwell Science, pp.101 – 102. ISBN 0 632-05025-59.

Plaut, M., Zimmerman, E.M. & Goldstein, R.A. (1996). Health hazards to humans associated with domestic pets. *Annual Review of Public Health*, 17, 221-245.

Rinzin, K. (2007). *The epidemiology of free-roaming dog and cat populations in the Wellington Region of New Zealand.* Master Thesis. Massey University. Palmerston North: Institute of Veterinary, Animal and Biomedical Sciences, Massey University, New Zealand.

Robinson, L.E., Miranda, M.E., Miranda, N.L. & Childs, J.E. (1996). Evaluation of a canine rabies vaccination campaign and characterization of owned-dog populations in the

Philippines. *Southeast Asian Journal of Tropical Medicine Public Health* 27, 250 – 256.

Schmidt, P.L. (2009). Companion animals as sentinels for public health. *The Veterinary clinics of North America. Small animal practice*, 39 (2), 241 - 250.

Schott, J.R. (2007). *Remote sensing: the image chain approach* (2nd ed.). Oxford University Press. p. 1. ISBN 978-0-19-517817-3.

Schowengerdt, R.A. (2007*). Remote sensing: models and methods for image processing* (3rd ed.). Academic Press. p. 2. ISBN 978-0-12-369407-2.

Schwarz, C.J. & Seber, G.A.F. (1999). Estimating Animal Abundance: Review III. *Statistical Science*, 14 (4), 427–456.

Sudarshan, M.K., Mahendra, B.J., Madhusudana, S.N., Ashwoath Narayana, D.H., Rahman, A., Rao, N.S., X-Meslin, F., Lobo, D., Ravikumar, K. & Gangaboraiah, B. (2006). An epidemiological study of animal bites in India: results of a WHO sponsored national multi-centric rabies surveys. *Journal on Communicable Diseases*, 38, 32 - 39.

Suzuki, K., Pereira, J.A., Frías, L.A., López, R., Mutinelli, L.E. & Pons, E.R. (2008). Rabies-vaccination coverage and profiles of the owned-dog population in Santa Cruz de la Sierra, Bolivia. *Zoonoses Public Health*, 55, 177 –183.

Swabe, J. (1999). *Animals, Disease and Human Society*. London: Routledge. Accessed October 3rd, 2012, from Google Website: http://books.google.pt/books/about/Animals_Disease_and_Human_Society.html?id=WzXNU-nru90C&redir_esc=y

Taylor, L.H., Latham, S.M. & Woolhouse, M.E. (2001) Risk Factors for Human Disease Emergence. *Philosophical Transactions of the Royal Society B:Biological Science*, July 29, 356.

Tenter, A.M., Heckeroth, A.R. & Weiss, L.M. (2000). Toxoplasma gondii: from animals to humans. *International Journal for Parasitology*, 30, 1217-58.

Thrusfield, M. (2007). *Veterinary Epidemiology,* 3rd Edition. Wiley-Blackwell. ISBN 978-1-4051-5627-1

Tran, A., Poncon, N., Toty, C., Linard, C., Guis, H., Ferre, J.-B. & Baldet, T. (2008). Using remote sensing to map larval and adult populations of Anopheles hyrcanus (Diptera: Culicidae) a potential malaria vector in Southern France. *International Journal of Health Geographics*, 7, 9.

University of Minnesota (2012). Center for Animal Health and Food Safety (CAHFS). Accessed November 11th, 2012, from: http:// http://www.cvm.umn.edu/cahfs/fact/home.html

van Aarde, R.J. (1984). Population biology and the control of feral cats on Marion Island. *Acta Zoologica Fennica*, 172, 107-110.

Wagner, M.M., Moore, A.W. & Aryel, R.M. (2006). Handbook of Biosurveillance. Elsevier Academic Press.

Walton, S.F. & Currie, B.J. (2007). Problems in Diagnosing Scabies, a Global Disease in Human and Animal Populations. *Clinical Microbiology Reviews*, *20*(2), 268–279.

World Health Organization (WHO), World Society for the Protection of Animals (WSPA) (1990). *Guidelines for dog population management*. World Health Organization (WHO/ZOON/90166), Geneva.

World Health Organization (1999). *Making a difference.* The world health report 1999. Accessed September 24th, 2012, from: http://www.who.int/whr/1999/en/index.html

World Health Organization (2006). Communicable disease surveillance and response systems. A guide to planning. Available from WHO website: http://whqlibdoc.who.int/hq/2006/WHO_CDS_EPR_LYO_2006_2_eng.pdf

World Health Organization (2012). *Rabies.* Accessed December 23rd, 2012, from: http://www.who.int/mediacentre/factsheets/fs099/en/.

World Organisation for Animal Health (2013). World Animal Health Information Database (WAHID) Interface. Accessed April 15th, 2013, from: http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/Diseaseoutbreakmaps

World Society for the Protection of Animals (WSPA) (2007). Surveying roaming dog populations: guidelines on methodology. Companion & Working Animals Unit. Accessed September 12th, 2012, from Blueprint for Canine Rabies Prevention and Control website: http://caninerabiesblueprint.org/Guidelines-on-surveying-roaming?lang=en

Yang, X., Yue, W. & Gao, D. (2013). Spatial improvement of human population distribution based on multi-sensor remote-sensing data: an input for exposure assessment. *International Journal of Remote Sensing*, 34 (15), 5569-5583.

8. Annexes

Annex 1 - Example of zoonoses transmitted by dogs and cats.

Type	***Disease***	***Agent***	***Animal species***	***Mode of transmission***	*Reference*
Bacterial	Anthrax	*Bacillus anthracis*	Dog, Cat	Spore inhalation and Ingestion	Hunter, Corbett & Grindem, 1989
	Glanders	*Burkholderias mallei*	Dog, Cat	Contact with infected horses	Acha & Szyfres, 2003
	Cat Scratch Fever (Bartonellosis)	*Bartonella henselae*	Cat, Dog (occasionally)	Being scratched or bitten by an infected cat	Hines, 2012
	Salmonellosis	*Salmonella* spp non typhoidal	Dog, Cat	Ingestion food of animal origin	Acha & Szyfres, 2003
	Leptospirosis	*Leptospira interrogans*	Dog	Direct or indirect contact with urine of infected dog.	University of Minnesota, 2012
	Lyme Disease	*Borrelia burgdorferi*	Dogs	Tick-borne	Hines, 2012
		Streptococcus sp. and *Staphylococci sp.*	Dog, Cat,	Direct or indirect contact with animals	Hines, 2012
Viral	Rabies	Rhabdoviridae, genus Lyssavirus	Dog, Cat	Infected animals bite	Beran & Frith, 1988
Rickettsial	Rocky Mountain Spotted Fever	*Rickettsia rickettsii*	Dog, Cat	Tick bite	Acha & Szyfres, 2003
	Ehrlichiosis	*Ehrlichia canis*	Dog, Cat	Tick bite	University of Minnesota, 2012
Fungal		*Sporothrix schenckii*	Dog, Cat	Cutaneous lesion infected with spore	Acha & Szyfres, 2003
		Microsporum spp	Dog, Cat	Carrier animal direct contact and infected inanimate object	University of Minnesota, 2012
		Trichophyton spp	Dog, Cat	Animal direct contact and infected objects	University of Minnesota, 2012

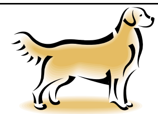
Annex 1 - Example of zoonoses transmitted by dogs and cats (continuation).

Parasitic	Toxoplasmosis	*Toxoplasma gondii*	Cat, Swine	Ingestion of oocysts of cat faeces	University of Minnesota, 2012; Evans, 1992
	Tapeworms	*Dipylidium caninum*	Dog, Cat	Ingestion of contaminated food or water	University of Minnesota, 2012
	Dirofilariosis	*Dirofilaria immitis, Dirofilaria tenuis*	Dog, Cat	Bite of mosquitoes	University of Minnesota, 2012
	Echinococcosis	*Echinococcus granulosus*	Dog, Cat	Ingestion of contaminated food or water	University of Minnesota, 2012; Hines, 2012
	Leishmaniosis	*Leishmania* spp	Dog, Cat	Sand flies	University of Minnesota, 2012
	Giardiasis	*Giardia lamblia*	Dog, Cat	Drinking contaminated water, person-to-person contact, eating contaminated food, and direct contact with infected animals	University of Minnesota, 2012
	Ascariasis (Roundworm)	Multiple *Ascaris* species (*A. lumbricoides, A. suum*)	Dog, Cat, Swine	Ingestion of contaminated food or water	University of Minnesota, 2012
	Strongyloidiasis	*Strongyloides stercoralis*	Dog, Cat	Careless handling of contaminated fecal materials	University of Minnesota, 2012
	Visceral Larval Migrans (VLM)	Toxocara genus (*T. canis, T. felis*)	Dog, Cat	Ingestion of eggs through direct contact with feces or contaminated materials	University of Minnesota, 2012
	Ancylostomosis (Hookworms)	*Angylostoma sp.*	Dog, Cat	Ingestion of contaminated food or water	Hines, 2012
	Sarcoptic Mange or Scabies	*Sarcoptes scabie*	Dog, Cat	Direct contact with the animal	Hines, 2012

Annex 2 - Dog observation registry (Portuguese)

Registo da observação e marcação dos animais – Ilha do Maio, Cabo Verde 2012

Ficha nº



Data	Localidade	Coordenadas (fonte de alimentação)	Tipo de detenção	Idade	Género	Esterilização	Desparasitação	Condição Corporal	Alterações Cutâneas	Observações
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	

Legenda Tipo de detenção 1- Animal com dono e acesso condicionado (sob contenção/supervisão do dono) 2- Animal com dono com acesso à rua* 3- Animal com "alguém" que os conhece, os alimenta e interage (Animal de bairro)* 4- Animal sem dono, que pode não ter a capacidade de sociabilização (Animal assilvestrado)* Idade Ju- Juvenil (≤6 meses) J- Jovem (>6 meses , ≤2 anos) A-adulto (>2 anos, ≤7 anos) S-Sénior (>7anos) Condição Corporal M- magro N- normal O-Obeso Lesões Cutâneas A- alopécia C- crostas D- descamação P- prurido *Estas classes incluem os animais classificados como errantes.

Annex 3 - Dog observation registry

Animals observation registry – Island of Maio, Cape Verde 2012

Sheet nr.______

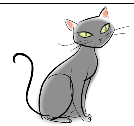
Date	Locality	Coordinates (feeding place)	Degree of restriction and dependence	Age	Gender	Sterilization	Parasites control	Body condition	Skin Changes	Other observations
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	

Legend Degree of restriction and dependence 1- Restricted or supervised (Fully dependent and fully restricted or supervised) 2- Family (Fully dependent; semi-restricted)* 3- Neighbourhood (Semi-dependent; semi-restricted)* 4- Feral (Independent, unrestricted. Although they may survive on human waste material nobody will take responsibility for them)* Age Y –Young (≤6months) J- Juvenile (>6 months, ≤ 2 years) A-Adult (>2 years, ≤7 years) - O-Older (>7 years) Body Condition T- Thin N- Normal F-Fat Skin changes A- alopecia C- crust P- peeling I- itch *These classes include the animals classified as stray or free-roaming animal.

Annex 4 - Cat observation registry (Portuguese)

Registo da observação e marcação dos animais – Ilha do Maio, Cabo Verde 2012

Ficha nº



Data	Localidade	Coordenadas (fonte de alimentação)	Tipo de detenção	Idade	Género	Esterilização	Desparasitação	Condição Corporal	Alterações Cutâneas	Observações
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	
			1 2 3 4	Ju J A S	M F	S N	S N	M N O	A C D P	

Legenda Tipo de detenção 1- Animal com dono e acesso condicionado (sob contenção/supervisão do dono) 2- Animal com dono com acesso à rua* 3- Animal com "alguém" que os conhece, os alimenta e interage (Animal de bairro)* 4- Animal sem dono, que pode não ter a capacidade de sociabilização (Animal assilvestrado)* Idade Ju- Juvenil ($\leq$6 meses) J- Jovem (>6 meses , $\leq$2 anos) A-adulto (>2 anos, $\leq$7 anos) S-Sénior (>7anos) Condição Corporal M- magro N- normal O-Obeso Lesões Cutâneas A- alopécia C- crostas D- descamação P- prurido

*Estas classes incluem os animais classificados como errantes

Annex 5 - Cat observation registry

Animals observation registry – Island of Maio, Cape Verde 2012

Sheet nr.______

Date	Locality	Coordinates (feeding place)	Degree of restriction and dependence	Age	Gender	Sterilization	Parasites control	Body condition	Skin Changes	Other observations
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	
			1 2 3 4	P J A O	M F	Y N	Y N	T N F	A C P I	

Legend Degree of restriction and dependence 1- Restricted or supervised (Fully dependent and fully restricted or supervised) 2- Family (Fully dependent; semi-restricted)* 3- Neighbourhood (Semi-dependent; semi-restricted)* 4- Feral (Independent, unrestricted. Although they may survive on human waste material nobody will take responsibility for them)* Age Y –Young (≤6months) J- Juvenile (>6 months, ≤ 2 years) A-Adult (>2 years, ≤7 years) - O-Older (>7 years) Body Condition T- Thin N- Normal F-Fat Skin changes A- alopecia C- crust P- peeling I- itch *These classes include the animals classified as stray or free-roaming animal.

Annex 6 - VSF-Portugal Companion animal health and welfare campaign questionnaire (Portuguese)

VSF – ILHA DO MAIO / 2012 Ficha nº _____________

LOCAL: ____ Data ____/____/______

Nome do Dono:_____________________________________ **Contacto/telefone**:________________

Morada:____

Nome do Animal: __________________ **Idade**____________ **Peso aproximado: ______** kg

Espécie: C F **Género**: M F **Castrado?** N S → Local e Data_______**____/______/______**

Fêmeas: nº de partos ___ Data último parto _____/______ Nº de cachorros__________

Raça: Indeterm. / Outra →________________**Pelagem**: curta / média / comprida **Cor:** __________

Habitat: Dentro de casa No quintal Com acesso limitado à rua

Com acesso livre à rua Na rua

Contacta com outros animais N S → Quais?____

Sempre viveu na Ilha do Maio? S N → Onde esteve? ____________________________________

Alimentação: restos de cozinha e mesa / ração / misto / outro Descrever: ____________________

Vacinado N S Qual? ___________________Data__________/________

Desparasitação interna N S → Qual? ___________________________Data_______/________

Desparasitação externa N S → Qual? ___________________________Data_________/________

Alguma vez esteve doente N S →____

Lesões cutâneas nos donos indicativas de possível zoonose parasitária? N S Obs:______________

EXAME CLÍNICO

Atitude: Alerta / Deprimido **Estado geral**: Magro / Normal / Gordo

Mucosas: Rosadas / Pálidas / Congestionadas **Pele**: Petéquias / Equimoses/ Alopécia / Descamação

Parasitas externos: S N →Carraças / Pulgas/ Outro Qual? ___________ **TRC**_________

Temperatura:_________ **Gânglios**: Normais / Alterados→____________________

Fezes: Normais / Diarreicas → ____

Outras observações:____

TRATAMENTOS:

Desparasitação: produto/dose ____

Cirurgia:____

Outros:____

COLHEITAS: Sangue com EDTA _____ Sangue para soro ______ Fezes _____

Carraças ___ Zaragatoa da orelha: ___ Zaragatoa do ânus_____ Outros:_____

Annex 7 - VSF-Portugal Companion animal health and welfare campaign questionnaire

VSF –Island of Maio/ 2012 Sheet nr _____________

Village: ____Date ____/____/______

Owner´s name:____ **Contact**:____________________

Adress:____

Pet´s name: __________________________ **Age**____________ **Weight: ______** kg

Specie: D C **Gender**: M F **Castrated?** N Y → place and Date __**_______/______/______**

Females: births nr ______ Last births date _______/________ Nr of puppies____________

Breed: Mongrel/ Other →_______________**Pelage**: short / medium / long **Colour:** _____________

Habitat: Inside home Garden Limited access to the street

Free access to the street On the street

Contact with other animal. N Y → Please specify which ones________________________________

Always lived on the Island of Maio? Y N → Please specify where __________________________

Feeding: kitchen swill / commercial animal food / both / other

Description:______________________

Vaccinated? N Y Please specify which ones ___________________Date__________/________

Internal deworming N Y → Please specify the product used ____________Data_______/________

External deworming N Y → Please specify the product used _______________Date______/______

Ever been sick? N Y→____

Are there any skin lesions in the owners indicative of possible zoonoses? N Y Please specify the lesions:____

CLINICAL EXAM

Attitude: Alert / Depressed **Body condition:** Thin / Normal / Fat

Mucosa: Normal / Pale / Congested **Skin:** Petechiae / Bruises/ Alopecia / Surface Peeling

External parasites: N Y →Ticks / Flies / Other **________** **RCT_________**

Temperature:_________ Lymph node: Normal / Reactive →**____________________**

Faeces: Normal / Diarrhea → **____**

Observations:____

TREATMENTS:

Deworming: product/dose ____

Surgery:____

Others:____

Collecting Samples: Blood EDTA _____ Blood Serum______ Faeces _____ Ticks ___ Ear swab:___ Others:_____